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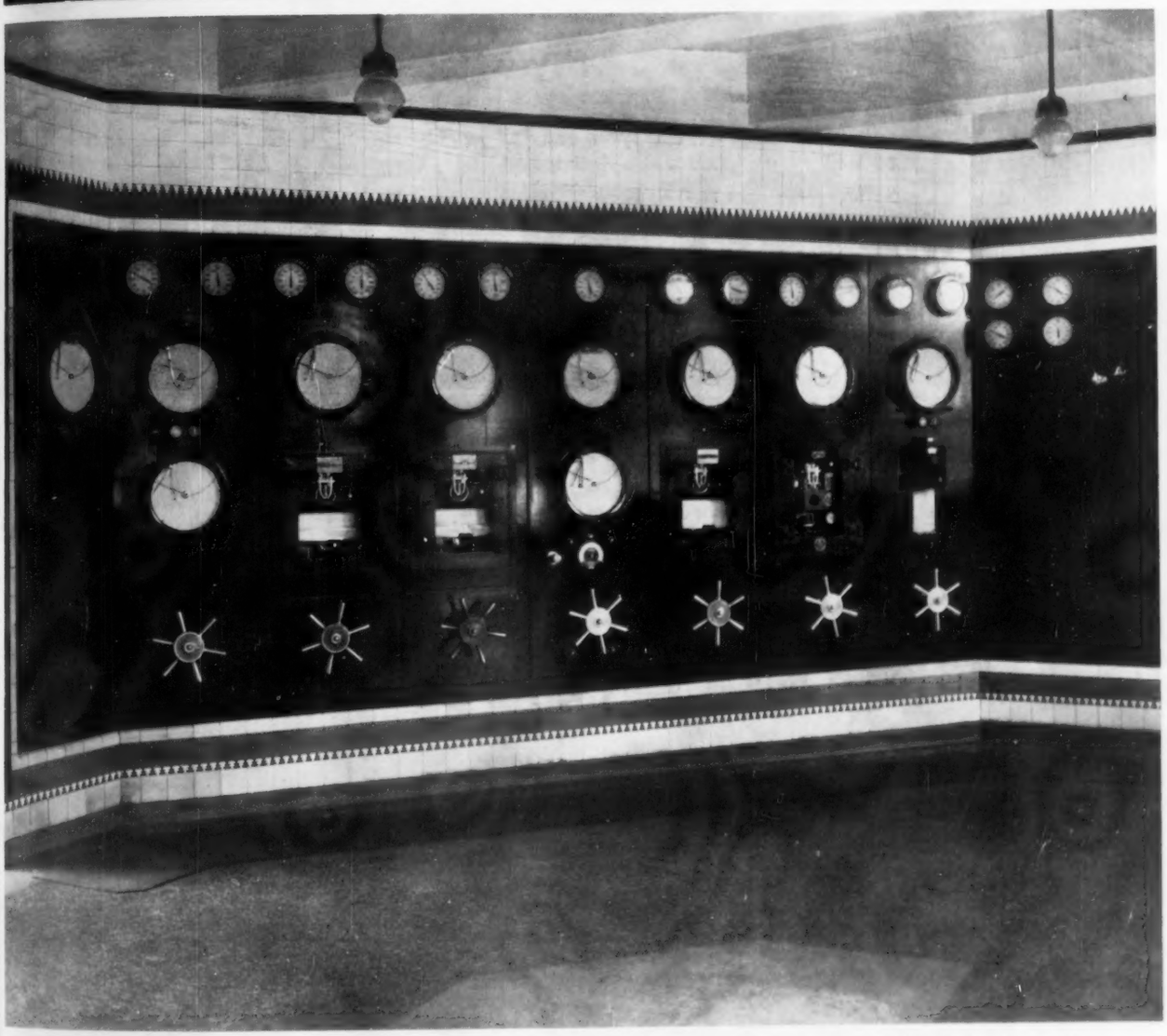

CONTROL ROOM FOR FOUR DeFLOREZ STILLS AT ATLANTIC REFINING COMPANY, PHILADELPHIA (*Courtesy of The Foxboro Company*)

TEMPERATURE and HUMIDITY MEASUREMENT and CONTROL

THE NAME

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NOW IDENTIFIES OUR COMPLETE LINE OF PRODUCTS, INCLUDING *Tycos* INSTRUMENTS

As of January 1, 1933, the Taylor Instrument Companies will generally replace the name Tycos with that of Taylor.

After that date, new types and designs of Taylor Instruments as well as containers, descriptive material and advertising will carry the name Taylor. Tycos-marked instruments, with a few exceptions, and Tycos material produced prior to that date, for sale during the year 1933, will carry our label stating, "The Name Taylor Now Identifies Our Complete Line of Products, Including Tycos Instruments," until their inventory is exhausted.

We consider it advisable to use one general trade name in place of two in the future to avoid any misconception about the uniform quality of Taylor products. This is a change long anticipated as a result of the continued growth of the Taylor Instrument Companies. It must be immediate in view of our plans to bring out new items and to start the most extensive advertising promotion ever undertaken by the Taylor Instrument Companies.

A recent survey of the United States convinced us that the name Taylor, placed on our products for homes, trade, professions and industries, will best represent the high standard of quality and accuracy established by the Taylor Instrument Companies through more than eighty years of business life.

President

Taylor Instrument Companies

ROCHESTER, NEW YORK

Taylor INDICATING, RECORDING AND CONTROLLING INSTRUMENTS

INDEX TO
INSTRUMENTS
THE MAGAZINE OF MEASUREMENT AND CONTROL

VOL. 6

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SUBJECT INDEX

A. C. Utility Meter 110
Air Cell, Compensated, for Potentiometers 111
Air Conditioning Control 105
Ammeter, Lightning-Bolt 195
Amplifier, Supersensitive 111
Anti-hunting Device for Pyrometric Control 102
Anubis Differential Pressure Indicator 64
Apparatus Supports 63
Area Meters 219
Auto-Gage, Tare Packaging 38
Automatic Control of Fluid Flow 53
Automatic Control Instruments Applied to the Zeolite Water Softening Process 215
Automatic System Supplies Proper Air Weight to Cupola 64

Balance, Sartorius Preliminary 109
Barometer, 50,000 Ft. Mercurial 21
Batchers, Automatic Cement 62
Bekk Smoothness and Porosity Tester for Paper 22
Boiler Regulator 84
Boiler Water-Level Meter 103
Boring Machine Combined with 3-Coordinate Measuring Machine, Precision 43
Bourdon Gage, Two-Inch 162
Breaker, Automatic Reclosing 110
Brewery Instrumentation 152

Carbon Dioxide Recorder Indicator 165
Carbon Dioxide Regulators for Beer Dispensing 166
Cases, Protective, for Watthour Meters 40
Clip-On Ammeters 193
Cold Bend Testing Machine 64
Color Comparator, Photoelectric 42
Colorimeter, Junior Model Hellige Duboscq 166
Color Matcher, Photo-Electric 164
Combustible Gas Analyzer 232
Combustion Recorders 128
Combustion System, Compensated 110
Combustion Test Set, Portable 229
Compact Switchboard Instruments 129
Comparators, "Microlux" 199
Control Circuits 62
Control of Fractional-Horsepower Motors 46, 69, 94, 118, 139, 155
Control, Full Automatic Pump 92
Control, Ignition 127
Control, Motor Speed 162
Control Power Unit 193
Control, Room Temperature 41
Control Switches, Temperature and Pressure 41
Control System Power Units 111
Controls, Time and Sequence 81
Counter, Resetting High Speed 16
Crankcase Dirt Indicator 197
Curtler Size Tester 231
Current Stabilizer for Instrument Calibration 93
Cutoff, Low Water 214
Cycle Splitter 214

Dial Indicator 49
Dial Thermometers 59
Dial Thermometer, Five-Inch 163
Differential Pressure Control Valve 214
Draft Gage Alarm 88
Draft Gage, Smoke Tube 88
Draft Gages, Dry Type Portable 44
Dusting or Fuzz Tester for Paper 22
Dynamic Weigher 86

Edgerton Stroboscope 23
Edgewise Thermometer 166
Electric Clock, Hand-less 91
Electric Taster 65
Electrical Instruments, Portable 66
Electrical Instruments, Portable 177
Engine Indicator 4, 27, 47, 71, 95, 116, 141
Escapement Integrator 65

Five Microscopes in One 229
Flatness Tester 126
Flaw Locator, Wire and Tube 88
Flow Indicator 146
Flow or Level Indicator 91
Flow Measurement and Control 7, 31, 53, 77, 97, 120, 143, 157, 171, 189, 207, 219
Flow Meter, Area 85
Flow Meter, Bell Type 84
Flowmeter, Four-Stage Fuel 212
Flowmeter, Photographic 199
Flow Metering and Control Instruments 109
Fractional H.P. Gear-Motors 150
Frequency Equipment 179
Fuses, Instrument 59

Gaging Several Diameters Simultaneously 104
Galvanometer, Pot 62
Gas Meters, Positive 79, 97, 120, 137, 143, 157, 171, 189, 207
Gas Regulators 167
Gear Tester, Optical 150
General Purpose Meter 41
General Purpose Meters 89
Gravitometer 181
Grinding Wheel Grader 41
Ground-Ohmer, Junior 125
Gulper for Liquid Meters 126

Hardness Tester, Wire 104
High Sensitivity Instruments, Rectox 149
Hot Wire Time Delay 102
Humidistat 39
Humidistat 194
Humidities, Recording and Producing Low 184
Humidity Control Resistance Thermometer 84
Humidity Controller, Open Contact, Low Voltage 128
Humidity Recorder, Direct Reading Relative 13
Hydrogenation Apparatus 127
Hydrogen Ion Tester, Wulff 107
Hydrometers 213
Hygrometer, Hair 109
Hygrometer, Hair 181
Hygrometric Instruments "Say When" to Lay Wood Floors Over Concrete Subfloors 25

Illuminator, Darkfield 89
Impedance Meter 39
Industrial Dial and Recording Thermometers 230

Level, Precision 148
Leveling Square, Precision 213
Liquid Displacement Meters 12, 31
Liquid Meter, Brewery 163

Magnetic Impurities Detector 92
Measuring Machine, Universal 61
Measurements of Crankshaft Whip and Vibration 75
Mercury Vapor Detector 211
Megger Tester, Midget 60
Metalloscope, Portable Type Fisher 164
Metallographic Microscope 89
Metering Unit, Electric 65
Meter Measures Current Without Being in Circuit 41
Microdensitometer 87
Micro-metallograph 87
Microphones, Grille Type 196
Microscope, Comparison 103
Microvolter 212
Milk Curd Consistency Tester 42
Mirror Telephoto System 214
Motor Method for Gasoline Knock Characteristics 179
Motor Starter 195
Moving Coil Meters 85

Noise Measuring Equipment 40
Null-Method Recorder 105

Oil Combustion Indicator 226
Oil Sediment Indicator 194
Opacimeter, Photoelectric 200
Operation Recorder 14
Optical Bench, Universal 180
Orifice Discharge Coefficients for Viscous Liquids 201
Orifice Metering, Fundamental Principles 187
Oscillograph Amplifier 232
Oscillograph, Cathode-Ray 178
Oscillograph, Portable 193
Oscillograph, Portable Cathode Ray 19
Oscillographs, Automatic 193

Paper Tester, Bursting Strength 110
Paper Testing Devices 22
Photo Cell 102
Photoelectric Cell Outfit 42
Photoelectric Cell, Self-Generating Dry-Disk 15
Photoelectric Color Comparator and Turbidity Meter 42
Photoelectric Controller 57
Photoelectric Kit 194
Photoelectric Meter-Alarm for Water Hardness 182
Phototube, Small Stable 212
Plastometer 92
Porosity Tester for Paper 22
Positive Meters 7
Positive Meters 31
Potentiometers, Indicating and Recording 63
Potentiometers, Indicating Models of Control 106
Potentiometer, "Speedomax" 211
Potentiometer Stabilog 58
Power Plant Instruments 103
Power Unit for Control Systems, Two-Position 112
Pre-determined Volume Liquid Meter Device 165
Prepayment Watthour Meter 226
Precision Regulators for High Pressure Gases 167
Pressure Controller, Electric Motor-Operated 178
Pressure Controllers 24
Pressure Gage, Absolute 179
Pressure Gages 59
Pressure Gages 212
Pressure Gage, Transmitting Oil 165
Pressure Indicator, Differential 64
Pressure Indicators, Internal Combustion Engine 233
Pressure Recorder-Controller and Flowmeter 129
Profile Grinder, Naumann 102
Profile Projector 228
Pyrometer Controller 67
Pyrometer, Recording 231
Pyrometers, Indicating 129
Radiation Pyrometer 232
Radio Devices 199
Rate-of-Flow Controllers 231
Reclosing Device for Oil Circuit Breakers 180
Recorder-Controller for Testing Machines 90
Recorder-Controllers, Electric Contact Type 17
Recorder, Operation 14
Recorder, Temperature, Portable 14
Recording Demand Gas Meter Was Developed, How a New 137
Regulator, Altitude 147
Regulators, "Dubl Response" 112
Regulator, Rheostatic, High Speed 18
Relay, Heavy Duty 4-Pole 125
Relay, Magnetic 15
Relay, Magnetrole 66
Relay, Mercury Swing Type 67
Relay, Motor-Driven Time Delay 127
Relay, Photoelectric 125
Relay, Photoelectric 214
Relay, Polarized 181
Relay, Self-Recycling Time Delay 106
Relay, Supersensitive 197
Relay, Tour Supersensitive Electrical 107
Relay, Vacuum Contacting A.C. 19
Relays, Bearing Thermal 197
Relays, Vacuum Contact 56
Resistance Box, Four-Dial 65
Resistometer 181
Rheostat, "Adjustat" 67
Rheostat, Coil Type 17
Rheostat, Ring Type 129
Rheostat, Tubular 196
Rheostats, Slide Wire 107
Roll Surface Pyrometer 232
Rotoscope 212
Round-Chart Recorder, Re-designed 66
Rubber Capped Plugs 214

Sag Meter, Kueppers 177
Scale, Portable Platform 182
Screw and Bolt Gage 233
Size Tester (Paper) 231
Slide Rule, Circular 60
Slide Rule Magnifier 198
Smoke Density Meter 91
Smoke Density Recorder 197
Smoothness Tester for Paper 22
Solution Feed Equipment 63
Spectrograph, Littrow 103
Spectrograph, X-Ray Fibre 166
Spectroscope with Wave-Length Scale, Miniature Quartz 125
Split Core Transformer Test Set 213
Split-Phase Motors 57
Square-Case Instruments 56
Stabilog 58
Starter, Hand-Operated 106
Starters, Explosion-Proof Manual Control 39
Steam Generator, Laboratory 104
Stiffness and Resiliency Tester 227
Stiffness Tester for Paper 22
Stroboscope, Edgerton 23
Stroboscope, Neon Tube 13
Stroboscope, Mercury Lamp 198
Stroboscope, Pocket 196
Stroboscopic Meter Standard 44
Stroboscope, Shutter Type 198
"Super-Meg" Tester 147
Supersensitive Instruments 177
Switchboard Instruments, Rectangular 182
Switches, Laboratory Plug 39
Switch for Fractional H.P. Motor, Starting 148
Switch, Heavy Duty Micro 149
Switch, Refractory Protected Mercury 128
Switch, Rotary Snap 58
Synchronizer, Automatic, for Sound and Animation 110
Synchroscope, Moving Iron Vane 88

Tachometers, Stationary 84
Tachometer, Stroboscopic 198
Tape Rule 163
Tensile Strength Tester 103
Tensile Strength Tester 199
Tension Indicators 61
Temperature and Pressure Controllers, Snap Action 182
Temperature and Pressure Recorder Controllers 128
Temperature Control Device, Multi-position 165
Temperature Controllers 24
Temperature Controllers, Air-Operated 107
Temperature Indicators and Recorders, Bodily 43
Temperature Indicator, Multi-point 125
Temperature Recorder 14
Temperature Recorder, Photographic 164
Testing Set, "Type U" 163
Test Set, Multi-range 195
Test Set, Portable 197
Thermionic Tubes, Graphite Anode Air Cooled 213
Thermometer, Free Air Strut 127
Thermometer, "Radif" 182
Thermometers and Pressure Gages, Aircraft Dial 129
Thermostat, Bi-metallic 19
Thermostat for Water Vapor 104

Thermostats, Single and Double Slide Wire Proportioning 107
Thickness Gage 182
Thickness Gage, Magnetic 212
Time Cycle Controller, Recording 213
Timer 88
Timer, Automatic 178
Timer, Automatic Weld 198
Timer, "Minuteminder" 164
Timers, Electric 179
Timer, Synchropulse 16
Time Switch, Automatic 227
Time Switch with Governing Device 178
Time Temperature and Time Pressure Controllers 150
Timing Contactor 225
Timing System Approved for Air Races 125
Tintometer, Lovibond 44
Torsion Impact Tester 225
Trans-O-Meter 146
Triple Service Aircraft Engine Unit 129
Tube Tester 21
Turbidity Meter, Photoelectric 42

Vacuum Gage, New Type 194
Vacuum-Pressure Gage, Remote Reading 103
Valve for Bleeding Gas Under Vacuum 126
Valve, Motorized Pilot 196
Valve, Pilot-Controlled, Self-Powered Water Regulating 66
Valves, Chronometer 196
Valves, Diaphragm 43
Valves, Large Motor-Operated 127
Valves, Motorized, Double Seated, Rotary Stem Lever, Control 106
Valve, Solenoid Safety Fuel 106
Valves, Solenoid-Operated Pilot 110
Valves, Solenoid Water 19
Valves, Throttling and Three Way 40
Valve, Water Circulating 180
Variac 180
Vectorial Components Measured Directly 195
Vibrometer, Portable 20
Viscometer 167
Viscosity, Automatic Control 7

Water Meters, Turbine 92
Watthour Demand Meters 92
Weigher-Filler, Automatic 136
Weighing, Precision Automatic 164
Weighing Meters 113
Weight Recorder 77
Weight Recorder, Automatic 232
Weights, "1-2-3-5" System 128
"Wrigraph" Draft Block 82

X-Ray Camera, Precision Back-Reflecting 189
Yarn Numbering Balance and Ruler 89

AUTHOR INDEX

Abrasive Engineering Corp. 41
Air Reduction Sales Co. 166, 167
Allen-Bradley Co. 106
American Askania Corp. 177, 214
American Instrument Co., Inc. 127, 180, 197
American Meter Co. 181
American Photoelectric Corp. 42, 91
Amthor Testing Instruments Co., Inc. 103, 110, 199
Aristo Import Co. 60
Automatic Electric Co. 19
Automatic Products Co. 19
Automatic Temperature Control Co., Inc. 112, 165, 225

Bacharach Industrial Instrument Co. 232
Bailey Meter Co. 65
Baldwin-Southwark Corp. 64, 90, 196, 225
Barber-Colman Co. 40, 104, 127
Bausch & Lomb Optical Co. 89, 103, 200, 229
Behar, M. F. 7, 31, 53, 77, 97, 120, 143, 157, 171, 189, 207, 219
Biddle Co., James G. 60, 147
Bonckley, George Sidney 64
Blodgett, R. S. 152
Bristol Co. 13, 150
Brodie Co., Ralph N. 165
Brown Instrument Co. 84, 85, 103, 111, 177, 213
Brush Development Co. 196
Bryden, S. D. 63
Buffalo Meter Co. 163
Burgess Laboratories, Inc., C. F. 149
Burton-Rogers Co. 21

Cambridge Instrument Co. 62
Chauvin Arnoux et Cie. 89
Cie. pour Fabrication des Compteurs & Materiel d'Usines a Gaz 92
Clardon Corp. 197
Close, Joseph K. 113
Cochrane Corp. 66
Columbia Electric Mfg. Co. 41
Commercial Engineering Laboratories 212, 233
Commonwealth Electric & Manufacturing Co. 104
Consolidated Ashcroft Hancock Co. 127, 128, 129, 212
Cutler-Hammer, Inc. 39

Defender Automatic Regulator Co. 128, 178, 196
De Juhasz, Kalman J. 4, 27, 47, 71, 95, 116, 141
Deming, George M. 167
Detroit Lubricator Co. 19, 41
Dry-Zero Corp. 182
Dubrovin, John 194
Ducasse & Son, F. 196, 198
Du Mont Laboratories, Allen B. 19, 232
Dunlap, M. E. 25

Eagle Signal Corp. 16
Eby Mfg. Co., Inc., H. H. 199, 214
Electric Controller & Mfg. Co. 92, 147, 195, 197, 198
Electrocon Corp. 13
Electronic Inspection Labs. 194
Elgin Softener Corp. 182
Ellison Draft Gage Co. 88
Ess Instrument Co. 226

Federal Products Corp. 40, 182
Ferner Co., R. Y. 43, 61, 104, 148, 150, 228
Ferranti, Inc. 193, 195
Ferris Instrument Corp. 212
Fish-Schurman Corp. 126
Ford Meter Box Co. 126
Forrest, John W. 200
Foxboro Co. 17, 58, 64, 84, 102, 129, 146, 162, 231
Friez & Sons, Inc., Julien P. 39, 105, 109
Fuess, Inc., R. 22, 180
Fuller Co. 62

Gaertner Scientific Corp. 21, 87, 125
General Electric Co. 18, 39, 40, 43, 62, 88, 91, 92, 111, 130, 148, 150, 162, 177, 178, 179, 180, 182, 195, 197, 211, 212, 227
General Radio Co. 23, 39, 40, 195
Gess, Louis 84
G-M Laboratories, Inc. 102, 107

Hart Mfg. Co. 66
Hays Corp. 44, 165, 229
Hellige, Inc. 166
Heusser Instrument Co. 42
Hilger, Ltd., Adam 166
Hill, B. R. 149
Hill Co., E. Vernon 88
Hygrade Sylvania Corp. 213

Illinois Testing Labs. 232
Industrial Pyrometer Co. 232
International Broadcasting Equipment Co. 179, 198
International Filter Co. 231

Jones-Motrola Sales Co. 84

Koch, A. H. 111
Kron Co. 182

Leeds & Northrup Co. 63, 106, 163, 211
Leitz, Inc., E. 87, 89
Leland Electric Co. 57, 84
Lewis Air Conditioners, Inc. 128
Littelfuse Labs. 59
Livingston & Southard 198
Lufkin Rule Co. 163

Marburg Bros., Inc. 199
Marsh Corp., Jas. P. 230
Marshall, C. O. 113
Martin-Decker Corp. 61
Metallascope Sales Co. 164
Miller, Carl D. 2
Milligan Co., Fletcher F. 231
Minneapolis-Honeywell Regulator Co. 24, 106, 107, 111, 193, 214
Mishawaka Industrial Instrument Mfg. Laboratory 129
Morey & Jones, Ltd. 84, 91

Negretti & Zambra 67, 107, 164, 165, 166, 179
Neilan Company, Ltd. 110
Nicholson & Co., W. H. 110
Northern Equipment Co. 214

Ohmite Mfg. Co. 63
Operadio Mfg. Co. 110
Oplinger, Kirk A. 130

Parker, W. W. 29
Pfaltz & Bauer, Inc. 92, 106, 199
Phipps & Bird, Inc. 83
Pick, Eric 213
Pitkin, Inc., Lucius 167
Practical Instrument Co. 14
Pratt & Whitney Co. 164

Rawlplug Co., Inc. 233
Replogle, D. E. 213
Rhamstine, J. Thos. 15, 214
Roensch, M. M. .....
Roller-Smith Co. 66, 213

Sangamo Electric Co. 229
Scherr Co., George 102, 213
Schreiber, S. M. 183
Scott Co., Henry 92
Shallcross Mfg. Co. 41, 110
Slip-Lens Co. 198
Smith, Ed S., Jr. 54
Smith-Taber Research Engineers 227
Sorg Paper Co. 231
Spangler, F. L. 46, 69, 94, 118, 139, 187
Spencer, James 90
Starrett Co. 102
Sprenkle, R. E. 201
Sticht & Co., Herman H. 125
Streeter-Amet Co. 178
Struthers Dunn, Inc. 67, 102, 187
Suter, Alfred 89

Tagliabue Mfg. Co., C. J. 43, 109, 163, 180, 182, 213
Taylor Instrument Co. 59, 66, 112
Texair Instrument Co. 194
Thwing Instrument Co. 187
Thyle Machinery Corp. 195
Tintometer, Ltd. 71
Toledo Precision Devices, Inc. 58, 86
Toledo Scale Co. 164, 214
Trimount Instrument Co. 199
Triplett Electrical Instrument Co. 85
Turner, W. H. 18
Tuve, G. L. 201

Universal Microphone Co., Ltd. 88

Van Keuren Co. 128
Veeder-Root, Inc. 16

Wagner, Walter C. 137
Walker, A. C. 184
Walser Automatic Timer Co. 164, 178
Ward Leonard Electric Co. 15, 17, 56, 67, 106, 125, 127, 129, 196
Warren, Kenneth H. 187
Western Electric Co. 42
Westinghouse Elec. & Mfg. Co. 20, 44, 56, 57, 65, 88, 105, 106, 110, 125, 127, 129, 146, 149, 164, 177, 193, 197, 211
Westinghouse Lamp Co. 128
Weston Electrical Instrument Corp. 191
Wirt Co. 58

BOOK REVIEWS

SUBJECT INDEX

Alternating-Current Bridge Methods 11
American Standard Practice for Inch-Millimeter Conversion for Industrial Use 131
A.S.H.V.E. Guide 1933 ..... A5 (Oct. issue)
A.S.T.M. Manual on Presentation of Data 220

Directions for the Use of the Askania Torsion Balance 81

Experimental Physics for Colleges 174

Glass Blowing 80

Handbook of Industrial Temperature and Humidity Measurement and Control 12
Handbook of Measuring Instruments 175
High-Frequency Measurements 131

Industrial Electric Heating 82
Industrial Electrical Measuring Instruments 176

Measurement of Air Flow 175
Microscope (Ultra Violet Edition) 80

Optical Pyrometry 124

Photoelectric Cell Applications 175
Photoelectric Phenomena 80
Photometric Standards 192
Principles of Optics 174
Profit Engineering ..... A5 (Oct. issue)

Regulators 192

Selenium Cell, Its Properties and Applications 98

Technical Materials, Their Properties, Defects and Testing 11
Testing Radio Sets 12
Thermionic Vacuum Tubes 220
Time Studies ..... A5 (Oct. issue)

AUTHOR INDEX

Behar, M. F. 12
Bernard, G. P. 98

Chaffee, E. Leon 220

Dubridge, Lee Alvin 99

Edgcumbe, Kenelm 176

Fleury, Pierre 192
Fraenkel, K. H. ..... A5 (Oct. issue)
Freund, Hans ..... A5 (Oct. issue)

Gage, Simon Henry 80
Gmelin, P. 192

Hague, B. 11
Ham, Lloyd B. 174
Hardy, A. C. 174
Helland, C. A. 81
Hughes, Llewelyn 99
Hund, August 131

Jakob, M. 192

Knoeppel, C. E. ..... A5 (Oct. issue)
Kronert, J. 192

Lance, T. M. C. 175

Ockenden, F. E. J. 176
Ower, E. 177

Perrin, F. H. 174

Reyner, J. H. 12
Ribaud, Gustave 128

Schneider, Walter A. 174
Schwarz, Otto 11
Stansel, N. R. 82

Walker, R. C. 173
Woytacek, Carl 89

INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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CONTENTS · JANUARY, 1933

A Novel Continuous Viscometer 2
Carl D. Miller

The Engine Indicator—Its Theory and Design 4
Kalman J. DeJuhasz

Flow Measurement and Control 7
M. F. Behar

Editorial Comment 1
Instruments Abstracts A3
Instruments Index A4
Advertisers' Index A8
Manufacturers' Literature 9
Instruments Book Shelf 11

New Instruments

Direct-Reading Relative Humidity Recorder 13
Improved Stroboscope 13
Portable Temperature and Operation Recorders 14
Re-designed Magnetic Relays 15
Self-generating Dry-disk Photoelectric Cell 15
New Synchropulse Timer 16
Resetting High Speed Counter 16
Electric Contact Type Recorder-Controllers 17
Coil Type Rheostat 17
Rheostatic Regulator With High Speed Features 18
Portable Cathode Ray Oscillograph 19
Bi-metallic Thermostat 19
Vacuum Contacting A.C. Relay 19
Solenoid Water Valves 19
Vectorial Components Measured Directly 20
Fifty-thousand-foot Mercurial Barometer 21
"Automatic" Tube Tester 21
Paper Testing Instruments Make Possible New Tests 22
The Edgerton Brilliant-illumination Stroboscope 23
New Types of Temperature and Pressure Controllers 24

A New Meter

For Low Pressure Measurement

◆ The many advantages of measurement with Inferential Type Meters . . . accuracy—dependability—low maintenance costs—permanent calibration—small compact meter stations—low pressure loss . . . are now available in measuring the flow of gas or air at low pressures. The use of a Foxboro Bell Type Differential Pressure Recorder with any of the primary devices—orifice plate, flow nozzle, venturi tube, or pitot tube—makes a Meter that opens a new era in low pressure gas measurement.

◆ The capacity for measuring large volumes and the ease with which the flow capacity can be changed make the Inferential Type Meter ideal for this type of metering. A single meter is capable of measuring as much gas as a whole battery of positive meters. Furthermore, should the flow conditions change and a meter of greater or less capacity be required, the same Inferential Meter can be adapted to the new conditions by simply installing a primary device of the correct size.

◆ The economies of the Foxboro Bell Type Meter should be investigated by every distributor of low pressure gas. Write for Bulletin No. 189.

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EDITORIAL COMMENT

In This Issue

♦ Back of every new instrument is an interesting story that generally starts with a vague "hunch" followed by research, development, amplification here and simplification there, and finally commercial production. When one man has the idea and carries it through by himself, he should be able to tell an interesting story as **Carl D. Miller** does about his **Vismeter** in this issue's first article.

♦ **Professor De Juhasz** is approaching the completion of his valuable book on The Engine Indicator and in this month's installment takes up modern **Electrical Indicators**, of which many have come out since we and our middle-aged readers went to engineering school.

♦ Containing the chapter on **Positive Meters** in "Flow Measurement and Control," **M. F. Béhar** deals this month with the characteristics of various instruments of this class which lately he has been thoroughly investigating not only for his Manual but for engineering bodies.

♦ Of the twenty articles in this month's **New Instruments** department, several announce a whole series of new devices, so that the total shows how the industry continues to "do the impossible" with a fine spirit.

♦ Do not let familiarity lessen your appreciation of the value of the other regular features: the **Manufacturers' Literature** department, the **Book Reviews**, the alphabetical **Instruments Index**, the conveniently arranged **Current Literature Abstracts** and last but not least the advertisements—all of them contain information of practical value to you, and the information is always easy to find.

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The Front Cover

♦ Honestly, now, wouldn't *you* like to be in charge of the De Florez stills at the Philadelphia plant of the Atlantic Refining Co. and work in the control room shown on this month's front cover? The way the instrument panels are "enshrined" in decorative tile indicates how refinery engineers value the benefits of Instrumentation.

Hats Off!

COURAGE, foresight and determination—these three words summarize one's impressions on returning from the A.S.M.E.'s Annual Meeting and the concurrent Power Show. Every committee meeting and open session of the Society, every new device at the show, could afford a text for a sermon of hope, but in this space we can only mention that instrument men participated prominently in the A.S.M.E. meeting, and briefly report on the inspiring number and variety of new developments by the "instrument industry" (including corporations with instrument-making subsidiaries).

While many other industries weep and sit back, the instrument makers gird up their loins and go forth to slay the depression dragon. Not with words, for they are neither unctuous politicians nor arrogant techno-economists, but with tangible, useful achievements. Our first thrill came on Sunday, before the show opened to the public, when we found old friends in shirt sleeves and overalls putting the final touches on "surprise" exhibits. Our biggest thrill the whole week? Hard to say. Anyway, here are just a few vivid memories:

By reason of its affiliation with Babcock & Wilcox and Fuller-Lehigh, the Bailey Meter Co. had part of an impressively large area on the main floor, advantageously displaying its new adjustable orifice, relay pressure valve, boiler water level recorders and of course its new fluid meter with Ledoux bell and Telechron-drive integrator. . . . Also in the center aisle as usual, the Tagliabue exhibit featured C. O. Fairchild's noteworthy recording potentiometer—the first multi-purpose industrial potentiometer employing photoelectric coupling of galvanometer and mechanism. Another TAG "surprise" was a differential pressure recorder with magnetic coupling of float and pen—the first *radial* magnetic coupling we know of in this field—and with working parts immersed in mercury. . . . One aisle away, Builders Iron Foundry had a unique and well-attended demonstration of new hexagonal-case Chronoflo receivers indicating, recording and integrating the steam flow from a huge boiler two miles away at the Edison East River Plant, and the Manhattan water supply flowing through the Catskill Aqueduct six miles away. . . . Across the aisle the new Brown mechanical flow meter was shown in action, connected to a glass orifice assembly and metering colored water (bubble-charged to make the flow visible); other new Brown electrical power plant instruments included a smoke recorder that flashed colored signals when we stuck our fist in the "duct" to simulate various smoke densities; the Brown potentiometer—a 1931 development but its first appearance at a Power Show; and an air-conditioning panel with handy dual controls. . . . Representing the greatest variety of strictly 1932 developments by one firm, the Bristol exhibit included their new Bakelite case electric contact type controller, their new humidigraph and thermo-humidigraph, new style surface and flush moisture-proof cases, a new process cycle controller, new absolute pressure recorder with modifications as a differential temperature or pressure controller in indicating and recording models, etc. . . . Leeds & Northrup had four of their new low-cost ten-inch round-chart Micromax indicating recorders in action, also a remarkable pressure-balancing primary device combining the dead-weight gage principle with the potentiometer principle; also a clever new multi-purpose case for the strip-chart Micromax. . . . Next to L & N, the Olsen people were showing their latest testing machines, some in use. . . . Across that aisle the Simplex Valve & Meter exhibit featured the new Elinco transmitting unit for telemetering which is used in the Catskill Aqueduct system. . . . The Electric Indicator booth was alongside with telemetering equipment. . . . At the Cochrane booth a new pilot-actuated valve seemed to have tremendous possibilities in the field of automatic control. . . . Consolidated Ashcroft-Hancock had a redesigned stationary tachometer with ball-bearings. . . . Both the Hays and the Ellison exhibits of draft gages and other power plant instruments attracted visiting engineers, the former including a new alum-

(Continued on Page 6)

A Novel Continuous Viscometer

By CARL D. MILLER

IN design and in operation this new instrument, intended for use with oil, represents a wide departure from all types of viscometers now available. It is designed according to a simple mathematical theory which has been empirically verified. (This theory is essentially that of lubrication, and the instrument, in use, makes an effective "demonstrator" of viscosity effects in lubrication.) Continuous in its action, it may provide, for example, continuous indications of the viscosity of the oil being treated in refinery processing. It may also be utilized as a means of automatic control, and also to obtain time records of viscosity. Finally, it possesses unique characteristics as a sample testing instrument.

Elementary Construction

The Miller Vismeter may be described as a journal and bearing, maintained at a suitable constant temperature, with the journal rotating at constant speed, and with a fixed clearance or working space between the journal and the bearing (see Fig. 2A). Under the two latter conditions the wedging action of the oil between the journal and the bearing may be measured by the pressure developed in the oil, and this pressure is a measure of the viscosity of the oil.

Theory of Operation

A few diagrams will bring out the theory. Fig. 1A shows two parallel plane surfaces, with the space between filled with oil, and with the lower surface sliding to the right at velocity V. The distance a between the surfaces remains constant. The oil clings to each surface, so that the oil on the lower surface moves to the right a distance V in one second. The oil on the upper surface remains at rest, and that in the intermediate layers moves at intermediate velocities, so that particles forming a line perpendicular to the surfaces at one instant will, after one second, form a slanting line—the initial and final positions being shown by the broken and solid lines in Fig. 1A. The motion results in a flow of oil to the right, which is represented by the area of the triangle, $\frac{1}{2}aV$.

Next, let the lower surface remain at rest, and apply a pressure p to the oil at the right, to produce a flow of oil toward the left. The extent of the wetted area is represented by L, so that the pressure p is entirely exerted in forcing the oil along between the surfaces for this distance L. The pressure produces a flow of oil given by the expression $(1/12)\ (a^3/L)\ (p/n)$ which holds for any such system of units as the centimeter-gram-second system or the foot-pound-second system. The number of viscosity units is represented by n.

Let the pressure applied be that which will produce the same volume of flow that was obtained with the arrangement of Fig. 1A. Then we may equate the two expressions for flow, and doing this, there is derived the expression

$$p = 6LVn/a^2.$$

Where this equality holds, if L, V and a are kept constant, p varies in direct proportion with n. That is, the pressure is proportional to the viscosity of the oil, and thus affords a direct and true measure of the viscosity.

To obtain this condition, all that is necessary is to have the lower surface slide to the right as shown in Fig. 1A, and at the same time to block off entirely the flow of oil to the right which this sliding tends to produce. A pressure results which sets up a flow of oil to the left, of the same character as that shown in Fig. 1B. The curve representing the flow is a parabola distorted by the sliding motion, by a pulling to the right in the lower part, a pulling which decreases toward the upper surface till it becomes nil, as given by the position of the slanted line in Fig. 1A. This action is represented in Fig. 1C. A circulatory flow is produced, with a flow to the right in the lower 1/3 of the space between the surfaces, and an equal flow to the left in the upper 2/3 of this space.

Fig. 2 shows the mechanism for obtaining this condition, the journal and bearing with fixed clearance a between surfaces in the working part. I have found that the journal may be upwards of an inch in diameter, and it may rotate at a speed somewhere in the range of 15 to 60 r.p.m. I am not aware of any *definite* limits in diameter or in speed, but many considerations make it certain that such limits exist. The oil is fed into the inlet cup, from which it goes to the working part of the instrument through a length of tubing which is held in the same constant temperature medium as the working part itself. This gives the oil opportunity to acquire the requisite test temperature before it gets to the working part. I may say that this feature has proved adaptable and adequate to meet any conditions that I have encountered, so that one need have no concern as to the temperature of the oil fed or put into the inlet cup. The readings obtained with the instrument are the same, no matter whether the oil is fed in hot or cold. The oil then passes around to the outlet, by the pulling or dragging

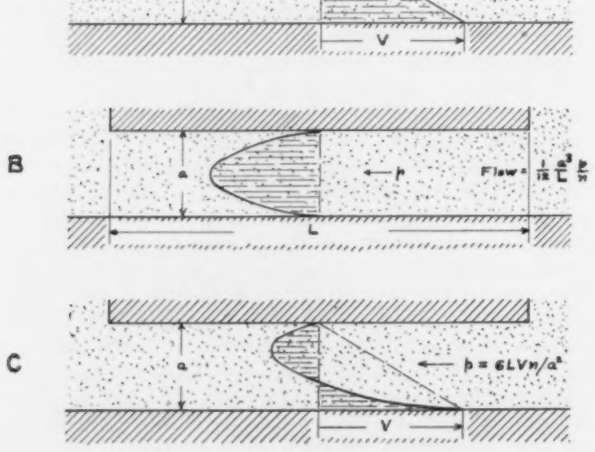

Fig. 1

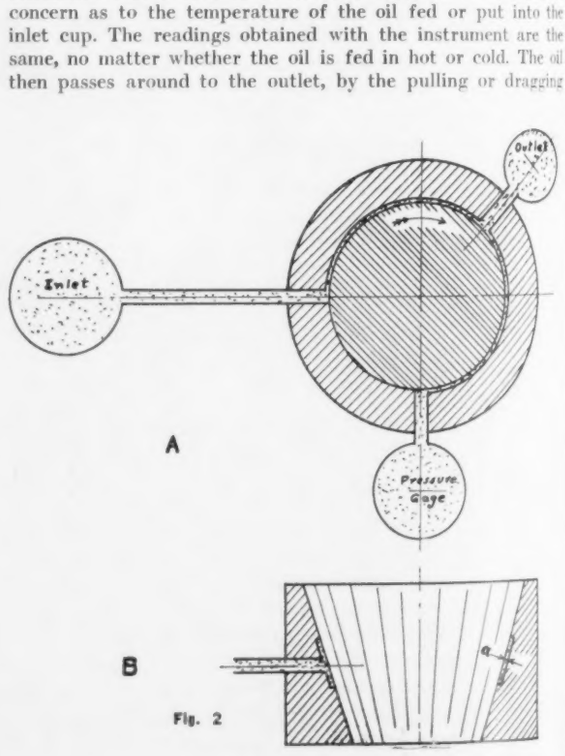

Fig. 2

action of the journal or rotor. While the temperature equalizing tube just discussed retards the flow somewhat, the condition between the inlet and the outlet may be considered to be roughly that represented in Fig. 1A. At the outlet the oil stream divides into two parts, the outer going directly out, while the inner part follows the moving surface of the rotor around to where the flow of the oil is blocked off, where the pressure gage is attached. The condition along here is that represented in Fig. 1C, the oil stream doubling back at the point where it is blocked off and returning to the outlet, through the outer part of the space between the moving surface and the fixed one.

Fig. 3 shows the flow of the oil through the working part of the Vismeter. If the oil entering the Vismeter is suitably divided into 27 zones of equal flow, it works out that 8 of these zones follow the rotor around to the pressure gage, while the remaining 19 zones go directly out from the first part of the working space.

The function of the first part of the working space is to draw oil into the instrument, overcoming the effect of the resistance of the temperature equalizer tube and other minor inlet resistance, and to supply or feed it to the second part. I therefore designate this first part as the *feeder duct*. The function of the second part of the working space is to take the oil from the feeder duct and develop the pressure which measures the viscosity. I therefore designate the second part as the *pressure duct*.

Established methods and practice make it necessary to obtain an index or reading in kinematic viscosity units, rather than in absolute viscosity units. Kinematic viscosity may be defined as the ratio n/d, in which d is the density of the oil. The necessary modification results in a simpler and more rugged instrument. The pressure is indicated by a liquid column gage in which the liquid is the oil under test, and this column is kept at the test temperature. The height of the oil is a measure of the ratio p/d, and the equation for pressure is readily put in the form

$$n/d = [a^2/(6LV)]\ (p/d)$$

This equation shows that n/d is measured by p/d. As the height of oil in the gage glass is a measure of p/d, it is also a measure of n/d, these being proportional.

The *centistoke* has been adopted by the American Society for Testing Materials, as the unit of kinematic viscosity. The oil column gage of the Vismeter is provided with a scale of centistokes on one side, and on the other side a scale giving viscosities directly in the desired terms of practice, such as Saybolt seconds, Redwood seconds, Engler degrees, and so on.

Verification

A number of Vismeters have been constructed, and tried out extensively. Instruments of a wide range of dimensions, with various drives and accessories, have been tested. Tests include continuous severe service for periods of many months under plant conditions, with checks against laboratory tests by conventional means. They include also careful observations with accurately controlled speed and temperature. They show that the Vismeter is suitable for use as a plant instrument, as an instrument for routine laboratory testing, and even as an instrument of precision. It has been proved for oils of the whole range of viscosities of petroleum lubricants, and it is to be remarked especially that it permits the accurate testing even of the thinner oils at the higher temperatures.

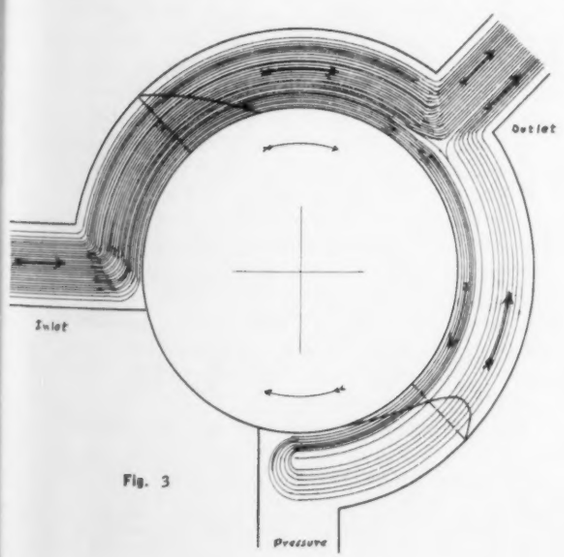

Fig. 3

Construction Details

As a result of testing various experimental models, it is possible to state that when commercial models are available they will in all likelihood be as follows: 10 in. in overall height, with a base 4 by 6 in., the gage affording a clear range of 6″ oil pressure, which covers a viscosity range which may be chosen freely within wide limits, depending on the depth to which the pressure duct is cut, the dimension a, and upon the speed of the drive. The rotor is of 1″ mean diameter, and the instrument should be driven at about 40 r.p.m. The driving unit consists of a small motor with built-in reducing gear, mounted on a special bracket or support. This unit is readily detachable from the body of the instrument, and the units are interchangeable. Constant speed induction motors, synchronous motors or electrically governed motors with speed adjustment can be supplied, to suit conditions. The gage glass is held in a copper bar which is in firm contact with the body of the instrument, the conductivity of the copper serving to keep the gage glass at the temperature of the body of the Vismeter. An electric heater and an air-cooled condenser constitute detachable parts, and permit holding the temperature of the instrument constant by means of a constant boiling liquid within it. A small switchboard at the back has connections for an ordinary electric cord, a heater switch, motor switch, socket for plug to connect the motor, and socket for connecting a resistance in series with the heater. Heater, condenser and switchboard are done away with where steam temperature is to be held and where there is a separate source of steam at hand. Provision is also made for connecting the instrument in a line in which a liquid at constant temperature is circulated by outside means.

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The ENGINE INDICATOR

Its Design and Theory

By KALMAN J. DeJUHASZ*

(Continued from December Issue)

ELECTRICAL INDICATORS

The endeavor to eliminate the undesirable characteristics of the optical indicator led to the development of several *electrical methods*. These consist, essentially, in measuring and recording the change in a direct current, or else, alternating current flowing in a circuit, in which

a. resistance;
b. impedance;
c. capacity;
d. electromotive force

are altered by the minute displacement of the pressure measuring element.[7]

With this method it is possible to use a pressure measuring device with very short period of vibration, i.e. with very stiff spring and consequently a minute displacement, taking advantage of the highly developed electrical measuring technique by which very small current variations can be measured with great accuracy. The important requirement is, however, that the translation of the pressure change into electrical terms must be consistent and free from error in itself.

The recording element of the electrical indicators is usually an oscillograph, which can be mounted at a distance from the engine under investigation. Oscillographs have been built with very short natural period of vibration; that of the mirror type can be as low as 0.0002 sec., which is far lower than that of any optical indicator hitherto built. In the cathode ray type oscillograph the magnifying lever is a stream of electrons which can be regarded as free from inertia in the mechanical sense of the word, as its natural period lies in the range of the higher radio waves. The inertia errors originating in the oscillograph can, therefore, be considered negligible at the engine speeds used at the present. The cathode ray requires only a negligibly small current for its deflection.

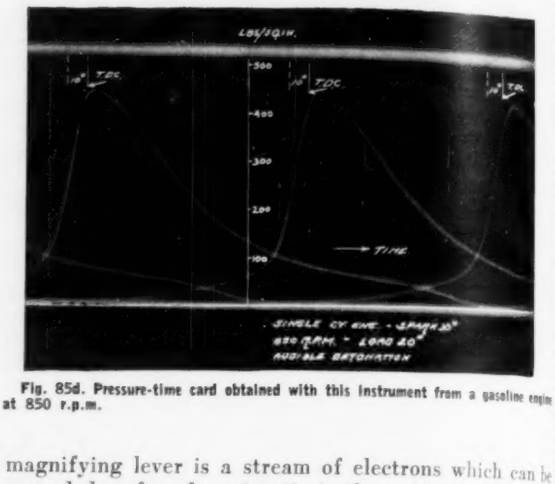


Fig. 85d. Pressure-time card obtained with this instrument from a gasoline engine at 850 r.p.m.

The application of the *resistance method a* is found in the electrical indicator developed by E. J. Martin and D. F. Caris in the General Motors Research Laboratory,[8] the principle of which is illustrated in Fig. 85a or b. It consists essentially of a Wheatstone bridge in which two carbon pile rheostats are incorporated. The resistance of these latter is varied by the pressure acting upon the pressure measuring unit, or rather by the resulting minute displacement of the carbon disks, i.e., the resistance decreasing with an increase of pressure and vice versa. The bridge-current is recorded by an oscillograph. The pressure acts upon a diaphragm the elastic force of which is negligible. The elastic force is exerted by a stiff cantilever spring, forming a tongue-like protrusion in the frame of the pressure element. The diaphragm is mounted flush with the inner wall of the engine cylinder and it is connected to the cantilever spring by means of an invar rod. It is stated that the deflection of the diaphragm is below 0.0005 inch and the natural period of vibration 1/3500 to 1/11,000 sec., according to the spring used. The extension of the cantilever spring is nipped between two carbon piles set under an initial compression. Deflecting the cantilever spring results in augmenting the compression and thus reducing the electrical resistance of one pile, and in relieving the compression and increasing the resistance of the other. A later type of this indicator has been built in combination with a spark plug in order to obviate the necessity for a separate opening in the engine cylinder. For the investigation of low pressure phenomena, special pressure measuring units have been built with a large diaphragm, weaker spring and incorporated air cooling.

The performance and accuracy of this instrument depends greatly upon the carbon pile. It has been well known for a long time that the electrical resistance

*Asst. Prof. of Engineering Research, Pennsylvania State College.

[7] K. J. DeJuhasz. Use of Electrical Indicators in Automotive Tests. *Automotive Industries*, Vol. 60, Apr. 27, 1929, pages 662-664.

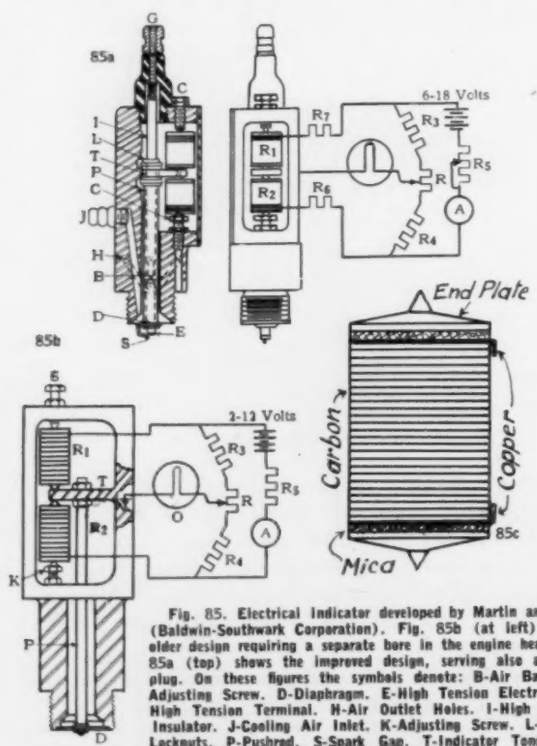
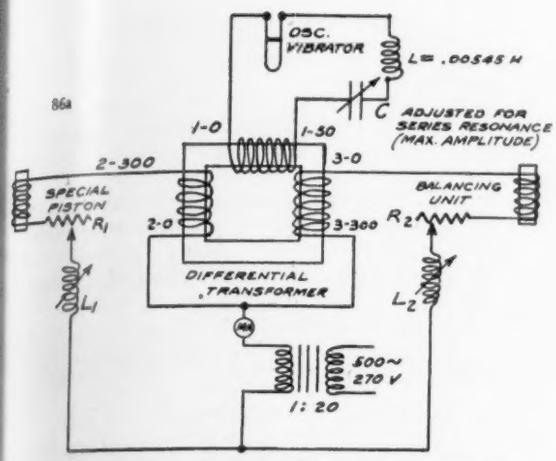


Fig. 85. Electrical Indicator developed by Martin and Caris (Baldwin-Southwark Corporation). Fig. 85b (at left) is the older design requiring a separate bore in the engine head. Fig. 85a (top) shows the improved design, serving also as spark plug. On these figures the symbols denote: B-Air Baffle. C-Adjusting Screw. D-Diaphragm. E-High Tension Electrode. G-High Tension Terminal. H-Air Outlet Holes. I-High Tension Insulator. J-Cooling Air Inlet. K-Adjusting Screw. L-Pushrod Locknuts. P-Pushrod. S-Spark Gap. T-Indicator Tongue. R-Balancing Rheostat. R_1 and R_2-Carbon Stacks. R_3 and R_4-Wire Wound Rheostats. R_5-Bridge Current Control. R_6 and R_7-Temperature Compensators.
Fig. 85c shows the construction of the carbon pile according to McCollum and Peters.

[8] E. J. Martin & D. F. Caris. A New Electrical Engine Indicator. *Journal Society of Automotive Engineers*, Vol. 23, July 1928, pages 87-97.

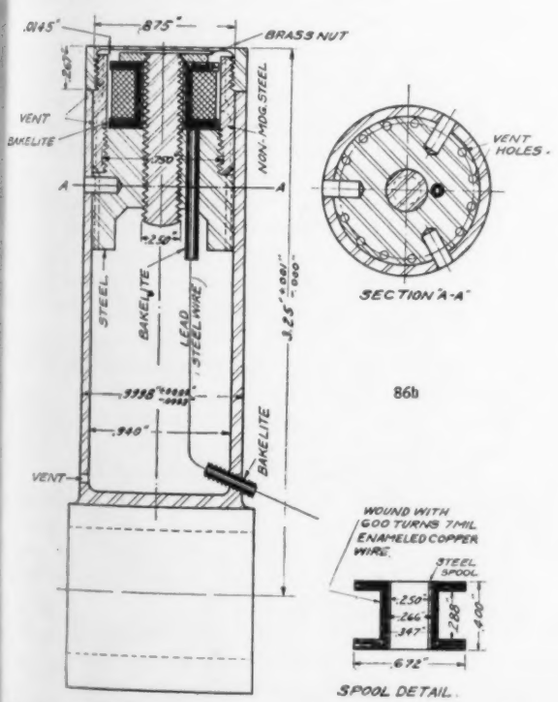


86a

Fig. 86a. Electric micrometer circuit used in Fiene's indicating apparatus for obtaining diagrams from a mechanical refrigeration unit.

of carbon contacts varied with the pressure but it was difficult to obtain reasonably consistent performance. The development of a satisfactory carbon pile is due to a great extent to the efforts of McCollum and Peters at the Bureau of Standards.[9] The most suitable material was obtained by carbonizing resin, this yielding the most resilient and hardest kind of carbon. The form found most suitable is that of an annular ring having 7/16 in. outside dia., 7/32 in. inside dia. and 0.020 in. thickness. Each ring is ground flat with optical accuracy. The initial pressure applied is about 180 lbs./in.^{2} The annular form gives stability to the pile against transverse shocks, and it also promotes cooling by its large heat radiating surface. For installation in the mountings the rings are stacked to the required length and provided at the ends with copper contacts, mica insulating disks and case

[9] Burton McCollum & O. S. Peters. A New Electrical Telemeter. *Bureau of Standards Technical Paper*, No. 247.



86b

Fig. 86b. Special piston used by Fiene, with the top serving as a diaphragm. The magnetic circuit about the coil is composed of the core, the air gap between the core and the diaphragm (0.005 in.), the diaphragm, the piston wall and the plug supporting the core.

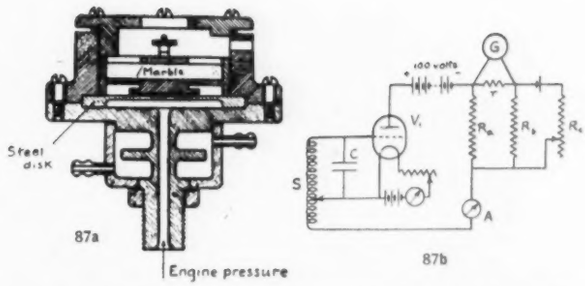


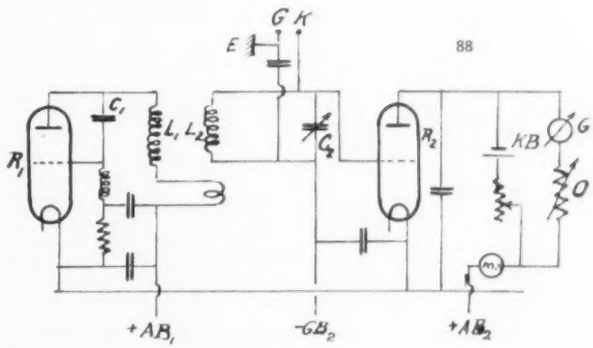
Fig. 87a. The pressure unit and the electrical circuit (Fig. 87b) used in Jichi Obata's electrical indicator. The steel disc is 2 mm. (3/32 in.) thick and of 2 in. dia. The indicator body is water cooled. An Einthoven string galvanometer G is used to record the current variations, which are proportional to the pressure.

hardened end plates with pivot points as shown in Fig. 85c.

The displacement-resistance curve of the pile is not a straight line, and this would necessitate the re-drawing of the card to a uniform scale. In order to avoid this trouble, two piles, having the same characteristics, are used the curves of which compensate each other in such a way that the sum of the resistance changes is a linear function of the displacement.

An example of the application of the *impedance method b* is the indicating device developed by M. Fiene[10] for testing a high speed compressor for household refrigerating use. The scheme is shown in Fig. 86a and b, the apparatus consisting essentially of a transformer with two differentially connected windings forming an alternating current bridge circuit with two inductances incorporated in the two branches. One winding is connected in series with a coil built into the moving piston of the compressor. The impedance of this coil is varied by the pressure acting on, and the consequent minute displacement of, a steel diaphragm forming part of the magnetic circuit of the coil. The difficulties of connecting electri-

[10] M. E. Fiene. Electrical Method of Obtaining Indicator Card of a Compressor. *Refrigerating Engineering*, Vol. 15, March 1928, pages 77-80.



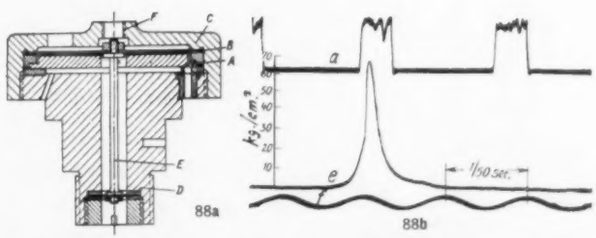


Fig. 88a. Indicating arrangement of the Deutsche Versuchsanstalt fur Luftfahrt. *D* is a weak diaphragm connected by means of rod *E* with the pressure measuring stiff diaphragm *B*. This latter forms a condenser together with the stationary and insulated plate *A*. The electrical circuit is shown on Fig. 88, incorporating vacuum tubes, balance coils and an oscillograph for recording the current variations.

Fig. 88b is a specimen card showing also the time scale and the position of the dead centers.

cally the coil in the moving piston with the rest of the apparatus (which is at rest) were overcome by means of a spring wire connection of safety pin shape. An oscillograph served as a recording instrument and a series of interesting cards were obtained. The alternating current used must have a frequency at least ten times as high as the frequency of the phenomena to be recorded.

An example of the application of *the capacity method c* is the electrical indicator developed by Jûichi Obata, in the Aeronautical Research Institute of the Tokyo Imperial University.[11] The principle of the instrument is shown diagrammatically on Fig. 87. An electric condenser forms part of an oscillating system. The capacity of the condenser is varied by the pressure on, and the consequent minute displacement of, a metal diaphragm which forms one of the plates of the condenser. The resulting changes in the voltage modulate a vacuum tube circuit the plate current of which passes through and is recorded by a string galvanometer, string electrometer, or, preferably, a Duddell oscillograph.

The German Aeronautical Experiment Station (Deutsche Versuchsanstalt für Luftfahrt) has also developed an indicator[12] in which the small displacements of the pressure measuring element are transformed into capacity changes of an electric condenser (Fig. 88a). In contradistinction with the indicator previously described in this latter instrument the pressure measuring element is separate from the condenser and is connected thereto by means of a rod. Thereby the undesirable temperature effects on the condenser are reduced. The electric circuit is shown in Fig. 88 and a number of cards in Fig. 88b. On this latter the wave of an alternating current serves for the measurement of time. Another line on the film marks the dead centers of the engine.

[11] Juichi Obata & Yahei Josida. An Electric Indicator for High Speed Internal Combustion Engines. *Report Aeronautical Research Institute, Tokyo Imperial University,* Vol. I.14, No. 28, Dec. 1927, 9 pages.

Juichi Obata. The Ultramicrometer, a New Instrument for Measuring very Small Displacement of Motion, and Its Various Applications. *Journal Optical Society of America and Review of Scientific Instruments,* Vol. 16, June 1928, pages 419-429.

Juichi Obata. The Ultramicrometer. *Paper delivered at the World's Engineering Congress,* Oct. 1929, 9 pages.

Juichi Obata & Yukio Munatomo. On the Possibility of Applying the Cathode Ray Oscillograph to the Indicator for High Speed Engines. *Report Aeronautical Research Institute, Tokyo Imperial University,* Vol. V.4, No. 57, Feb. 1930, pages 93-100.

[12] K. Schnauffer. Indizieren von Schnellaufenden Motoren. *Zeitschrift des Vereines deutscher Ingenieure,* Vol. 74, July 26, 1930, pages 1066-1067.

K. Schnauffer. Messung oszillierender Druecke nach der Kondensatormethode. *Archiv fuer Technisches Messen,* Vol. 1, Dec. 1931, 2 pages.

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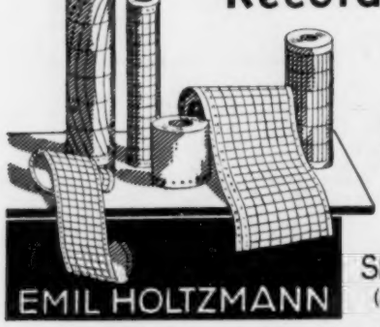
Correction

On page 288 of the December issue of INSTRUMENTS we described the Askania Primary Element Temperature Control System. An incorrect illustration was used in the description.



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EDITORIAL COMMENT

(Continued from Page 1)

inum case portable gage and the latter a standard A.S.M.E. Pitot tube. . . . From a distance the new Ashton electro-pilot gage caught our eye—as it is meant to catch the fireman's. . . . Improvements were noted in the new Sarco temperature regulators as well as in their thermostatic and float traps. . . . Dominating a corner on the 47th street side, the Republic Flow Meter exhibit featured panels with new combinations of indicating, recording and integrating units—some thoroughly redesigned. . . . In the Jenkins Valve, Yarnall-Waring and Watts Regulator exhibits, too, we found evidence of uninterrupted development activities.

On the second floor of the Palace, Taylor Instrument Companies proudly featured, among various indicating, recording and controlling instruments, their new "Accuratus" tubing for mercury thermal systems. . . . Facing them was a Minneapolis-Honeywell exhibit largely made up of 1932 developments: "Modutrol" miniature proportional control motor for space-heater applications, super-sensitive temperature and pressure regulators, "proportioning" control systems with electrical balancing with Brown or L & N potentiometers—the former actually having fewer parts than standard as made up for this service. . . . To the right and left of Minneapolis were two electrical instrument exhibits, Roller-Smith and Weston—the latter including various Photronic cells and both showing new instruments. . . . Along the same East row we noted Federal Gauge, Merrick Scale (with a Weightometer in operation) and Mercoid, this last featuring machine-made tipless mercury switches, the new "ball of mercury" principle, a 7-day timer with 7 distinct 24-hour cycles, and a silent transformer relay. . . . Large and impressive was the combined exhibit of Mason and Neilan at the next corner, featuring their new instrument-type controllers. . . . At the Fulton Sylphon booth we found several 1932 model industrial temperature regulators. . . . In the next booth was shown the latest Ray Pressure Snubber with new stainless steel parts. . . . The Foxboro exhibit, dominating the main north-south aisle, glittered with cut-away instruments with polished-up "innards"—in particular a Rotax and a Stabilog, each so attractive we got cross-eyed trying to admire both at the same time. . . . Veeder-Root featured among other new devices a resetting high-speed counter so made that it cannot "jump." . . . And before we go upstairs let's not forget that Permutit, Bausch & Lomb, Wallace & Tiernan, Kron Scale and American Blower also deserve honorable mentions.

Only two strictly instrument firms were on the third floor of the Palace. The Amthor Testing Instrument Co. as usual had an interesting variety including a new tensile strength tester and a new "automatic fixed reading" tachometer. . . . A new cooling jacket for their standard radiation tube, and new surface pyrometers, were among the Pyrometer Instrument Co.'s developments. . . . But on that floor were many exhibits of switches, relays and numerous other devices all clearly within the field of Instrumentation: Struthers-Dunn, Industrial Controller, Square D, Ward-Leonard, Power Control Corp., American District Steam, and Automatic Switch. . . . No doubt others we fail to remember by name, for our mind still reels with the profusion of tangible evidences of courage, foresight and determination on the part of those thousands of unsung heroes whose intelligent, purposeful efforts are helping Industry turn the corner—the Instrument Makers.—M. F. Behar.

Flow Measurement and Control*

By M. F. BEHAR†

CHAPTER XXIII
POSITIVE METERS

5. Liquid Volumeters—Standards and Calibration

(continued)

Equipment

The minimum equipment required comprises such obvious essentials as a calibrated tank, suitable connections, a quick-acting valve, a valve for establishing the flow rate, and a timepiece.

Hydrometers, viscometers and thermometers should be used whenever there is uncertainty as to whether the fluid used in tests has the same properties as the one to be metered in actual service; also wherever the fluid to be metered varies in gravity or viscosity. Surprising data may be disclosed by running a series of registration tests with everything equal except, say, the temperature of the metered fluid; or even by comparing the curves shown by a meter with two gasolines. It is almost incredible what a huge difference a couple of degrees Baumé or a few seconds Saybolt make in the performance of some meters. . . This, by the way, is an excellent criterion of the degree of positiveness, for a perfectly positive displacement meter gives equal readings when equal volumes of liquid are passed through, whatever be the viscosity.

Thermometers may be considered "essential" equipment wherever weights are to be converted to volumes, or where the purpose is the accurate testing of any meter, whether gravimetric or displacement, whether open or closed.

For testing all displacement meters, even those discharging to atmosphere in actual service, the use of both static and differential pressure measuring instruments is strongly recommended. In order properly to measure the "friction," "absorption" or pressure loss across a meter at various line pressures and rates of flow, it is imperative that a qualified engineer specify the details of the upstream and downstream pressure taps and connections and that he inspect them himself. Even the purchase of a pair of high-grade piezometer rings is not enough. (See §11 of Chap. XXV in this book, and for more details Chap. XVI in Part Four.)

Almost every piece of equipment required for any of the above-mentioned tests and calibrations of liquid volumeters is commercially available, except that calibrated tanks for the larger sizes of meters usually have to be designed and built rather than merely assembled on the spot from commercially produced parts. The availability of testing outfits, comprising everything required for the simplest "proof" tests of widely-used meters, is quite a convenience as it provides nuclei to which may be added the equipment required for more significant tests. These outfits are made of suitable materials for water and for petroleum products. Fig. 23-9 shows the water meter prover regularly produced by the Pittsburgh Equitable Meter Co. for proving meters up to the 2″ size, and this firm makes larger provers to order. The scale-board shows the percent error without calculation. There is "an accurately made orifice valve with wheel which can be set to deliver any flow not exceeding a 1″ orifice." Fig. 23-10 shows one of the meter testers regularly made in four sizes by the Ford Meter Box Co., and a pair of calibrated tanks made by the same company in capacities up to "75-gal." (90-gal. actual). The "No. 5" Ford meter tester is made for proving at one time five water meters in series, each meter being clamped water-tight in a few seconds and quickly removable without disturbing the others. The Ford tanks have scales giving the percent error without calculation. The H. W. Clark Co. makes testers and *weight tanks* having special scale beams.

Calibrated cans, buckets and other containers—the larger sizes on wheels sometimes termed "buggies"—are readily available.

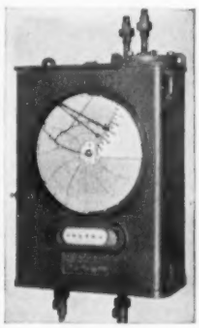
With ingenuity and resourcefulness, equipment not designed originally for the testing of displacement volumeters can sometimes be adapted to that purpose. A tank truck, for example—provided that its compartments have

* Part Six of *The Manual of Instrumentation.*
† Engineering Editor.

PRESSURE INDICATORS

Extremely accurate gages embodying the dead weight gage tester principle are available in several sizes up to 36 inches in diameter for indicating at remote points the pressure of steam, water, gas, etc. These gages can be used with any pressure and are particularly suitable for magnified ranges. Ask for bulletin No. 110.

BOILER METERS



For generating steam at the lowest cost, the Bailey Boiler Meter is an important accessory on any boiler of 100 h. p. or larger. This meter records and totalizes Steam Flow from the boiler, records Air Flow supplied for combustion, and records Flue Gas Temperature. The operator is furnished, therefore, with the information essential to obtaining smooth, economical performance of the boiler. Write for Bulletin No. 44 describing how Bailey Boiler Meters can cut your expenses.

FLUID METERS

Bailey Fluid Meters are the best solution to the problem of metering steam, gas, water and other liquids. Simple, rugged and extremely accurate, they can be depended upon to give long, trouble-free service. Bulletin No. 300 describes their many outstanding features. Write for a copy

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Earl N. Webber, Daily News Bldg., Chicago, Ill.

been accurately calibrated shortly before and that it has not been deformed —may be used as a measure although it certainly cannot be considered a "standard of liquid measure."

While weighing methods introduce possibilities of errors, the use of scales for testing volumeters affords some advantages, among which is that when testing at a given flow rate, the shut-off can be made abruptly, without tapering off or changing to a much smaller flow toward the end—which often has to be done where a narrow-neck calibrated container is not used.

Portable Test Meters, while they are not standards of volume, serve a useful purpose in that they make it possible to test meters in service and to discover quickly and conveniently all meters which are being overworked or which have been damaged. A good portable test meter need not be of the same size as the meters to be tested: it can be used to prove meters of several times its capacity. Some makers supply portable test meters similar in the main to their regular quantity-production meters but extremely carefully constructed, finely adjusted and embodying special registers with hands that make one revolution for a smaller unit than the usual final dial.

Strainers. Although these are not essential items of testing equipment, we mention them here as a reminder that they absorb pressure. Where the pressure loss is an important factor and the results of tests on competitive meters are being considered, it may not be amiss to ascertain not only whether such conditions as rate, gravity, viscosity, etc. were alike, but also whether some meters were tested with strainers in the line and others without. The same applies to other adjuncts of displacement meters.

Precision of Test Instruments. All gages, manometers, thermometers, hydrometers, viscometers, etc., should not only be accurate but should possess the sensitivity and degree of precision compatible with the best maximum-error guarantee accompanying the meters to be tested. This applies especially to other tests than the mere proving of a meter. For example, an inexpensive disk meter may be guaranteed by its maker to have been provided with such a gear train and to have been adjusted in such manner that its maximum error on the particular application for which it is submitted will be 0.5% at all rates of flow between 20 and 80% of its capacity flow. Now, if this application be metering an oil of *stated properties,* the test engineer should strive to duplicate on his test bench the temperature, gravity, viscosity and pressure conditions of the oil at the point of metering—as the meter manufacturer states that he has done. If then the meter apparently shows a greater error, this may be due (1) to the meter itself, or (2) to inexact reproduction of application conditions, affecting the meter which is of a type with a considerable *slippage that varies with the properties* of the metered liquid. Cause No. 2 cannot be eliminated as a possibility unless the tester has means of accurately measuring these properties.

The most important piece of equipment, of course, is the measuring tank. Its calibration should be absolutely trustworthy; it should not only be safeguarded against injury but should be re-calibrated whenever necessary (for example after painting the inside); its volume should not be confused with that of the hose or any other connection; allowance should be made for such temporary conditions as a film of oil which remains after the first run and decreases the volume up to the mark for subsequent runs; and if the tank is located in a room where the temperature fluctuates, a temperature correction curve should be established and used.

6. Gravitational Volumeters

(a) Types and Characteristics

The principle employed in all gravitational volumeters differs but slightly from the manual measuring of a quantity of fluid by filling and discharging a calibrated container. Automaticity is achieved by many means, so that there is a variety of meters. The majority of these can be divided into two general types, namely the tank and the drum.

Most tank volumeters, in turn, divide themselves into three main types. The first comprises meters the tanks of which have no valves but discharge by tilting; the second comprises meters characterized by stationary tanks discharged by syphon and similar arrangements; the third includes all meters with stationary tanks discharged through bottom valves.

Rotary drum volumeters are all alike in their essentials and there are no "types" other than various models.

Outside of this division into types there is a practical classification of all gravitational volumeters—into open or atmospheric models and closed or

pressure-tight models. This refers more to the construction of the enclosure or shell and has little to do with the characteristics derived from the working parts proper, but it may be an important factor in the selection of a meter and the availability of pressure models must not be lost sight of.

The most obvious characteristic of gravitational volumeters of all types is that the loss of head is the actual altitude difference between inlet and outlet. Another is close approach to ideal positiveness, which means that a dribble is measured as accurately as normal flow—the same as with weighers—but which does not necessarily imply close approach to ideal accuracy. In all models there are inevitable sources of error related to the degree of precision with which (1) the tank or compartment is filled up to a given point, or (2) the trip or discharge valve is timed. The errors are generally well within 1% of perfect registration; it appears from accuracy curves obtained by the author that these errors are mostly positive, few meters ever reading "slow"—which rather upsets preconceived notions.

Tank types register intermittently and the final dial on the register may be an inconveniently large unit where the flow during a short interval has to be determined. Rotary drum types operate continuously and may be provided with close-reading registers.

Accuracy is affected by deposits, which make a meter "fast," as in the case of weighers. See §4 for various other characteristics which gravitational volumeters have in common with weighers, but note that syrups, heavy oils, etc., cannot be metered satisfactorily by the gravitational volumeters on the market, all of which seem to have been originally designed for metering water and other liquids of low viscosity.

(b) Tank Types

Single Tank

The *Wilcox* represents this type of gravitational volumeter although it has always been called a "water weigher." Its tank has two compartments, one above the other, communicating by a round opening in the center of the partition, which opening is intermittently sealed by a standpipe. This standpipe is moved up and down by the action of the metered liquid and of the body of air which is always trapped between liquid surfaces and the sealed top of the upper compartment. To make the meter factor constant, a bell float in the lower chamber and a syphon device are also employed. The register is a counter operated by a separate float in the lower compartment. This meter is not a simple syphoning type, there being a "valve" as described, between the two compartments.

Duplex Tank

This type comprises a single tank or bucket divided into two compartments alternately filled and alternately dumped.

Adsco "Simplex" (American District Steam Co.). This meter was designed especially for metering steam condensate but can measure various liquids of low viscosity. As is apparent from Fig. 23-14 it has a two-compartment dumping bucket. This is made of heavy sheet copper; the body is of cast iron, and vacuum types are available. Dash pots filled with water (or whatever the metered liquid is) cushion the bucket and prevent its rebounding. Seven sizes are made. The smallest has an hourly capacity of 150 lb of condensate, weighs 53 lb and is 14″ long; the "No. 6" is rated at 1500 lb/hr., weighs 206 lb and is 26″ long; the largest handles 15000 lb/hr., weighs a ton and is 53″ long. Units of weight are used in designating sizes because these meters are chiefly used to measure steam, the quantity of which is thus expressed in power plant work. They "are accurate within a fraction of 2%."

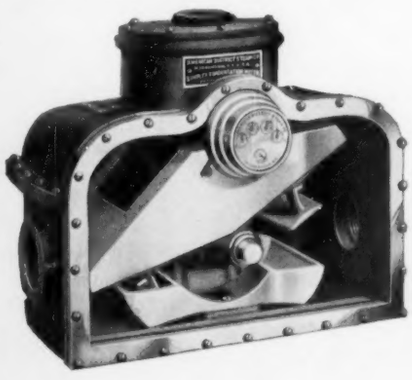


Fig. 23-14

WANTED:

(1) Two-element recording thermometer, with flexible tubing; (2) Recording wet-and-dry bulb thermometer. These instruments must be in good condition.

Write Box 3, Instruments, 3619 Forbes Street Pittsburgh, Pa.

MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

A1 **Laboratory Testing Equipment.** Catalogue 78 illustrates and describes standard Burrell gas analysis apparatus, electro analysis apparatus, high temperature furnaces and other testing equipment. Burrell Technical Supply Co., Inc., 1942 Fifth Avenue, Pittsburgh, Pa.

A2 **Thermometers.** A new publication consisting of 87 pages has just been issued by the Moeller Instrument Co., 261 Sumpter Street, Brooklyn, N. Y., and covers mercury and dial indicating thermometers, mercury vacuum gages, etc.

A3 **Draft Gages.** Bulletin No. 15 describes the portable draft gage sets. Ellison Draft Gage Co., 214 West Kinzie St., Chicago, Ill.

A4 **Recorders.** A circular describing a practical recording thermometer which records temperatures accurately. Practical Instrument Co., 2717 N. Ashland Ave., Chicago, Ill.

A5 **Checking Equipment.** The Franklin Radio Corp., Dayton, Ohio, have issued a bulletin illustrating and describing a portable tube checking equipment, which tests all tubes announced to date.

A6 **Thermostat.** The Central Heat Appliances, 343 South Dearborn St., Chicago, Ill., describe in their Bulletin No. 25 by means of a diagram the operation of their infiltration thermostat and master control.

A7 **Recorders,** for power plants based on many important new developments are described in a new 8 page pamphlet published by the Taylor Instrument Cos., Rochester, N. Y.

A8 **Thermometers and Gages.** Dial Thermometers and Dial Pressure Gages are illustrated and described in Catalogue 8000-D issued by Taylor Instrument Cos., Rochester, N. Y.

A9 **Temperature Regulator.** Temporary Bulletin No. 805 describes the No. 9-E Regulator which is a remote control instrument for controlling the flow of steam at a point distant from the thermostat or switch location. Fulton Sylphon Co., Knoxville, Tenn.

A10 **Unit Heater Regulator.** Temporary Bulletin No. 802-A describes a unit Heater Regulator No. 7, a device that gradually opens or closes its valve to modulate the steam supply to one or a gang of unit heaters. Fulton Sylphon Co., Knoxville, Tenn.

A11 **Heating Specialties.** Temperature Regulator for brine control in refrigeration and for heat control in industry are described in a new publication printed by the Sarco Company, Inc., 183 Madison Ave., New York.

A12 **Sperryscope.** Vol. 6, No. 11 of this publication features the following: Locating Airplanes by Sound; The Genesis of Flight Instruments, etc. Sperry Gyroscope Co., Inc., Manhattan Bridge Plaza, Brooklyn, N. Y.

A13 **Power Plant Recorders.** Circular 299-G describes Micromax recorders for power plants. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

A14 **Stroboscope.** A new Stroboscope is described in the December 1932 issue of the *Experimenter* issued monthly by the General Radio Company, 30 State Street, Cambridge A, Mass.

A15 **Rectifiers.** 16 page publication identified as C-1907-B describes sectional mercury arc rectifiers. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

A16 **General Purpose Meter.** Bulletin No. 152 describes the No. 610 general purpose meter which was designed to provide facilities for a wide range of electrical measurements. Shallcross Mfg. Co., 700 Parker Avenue, Collingdale, Pa.

A17 **The Graphic.** No. 5321 of this publication contains articles on the following: Recording Stream Contamination; Time Recorders on Circuit Breakers; Recording Water Levels, etc. The Esterline-Angus Co., Indianapolis, Ind.

A18 **Reflection Meter.** Bulletin No. 108 describes the APC Photoelectric Reflection Meter designed to compare and measure the total reflection factors of opaque materials. Eimer & Amend, Third Ave., 18th to 19th St., New York.

A19 **Controllers.** Catalogue 1603, Section 1 presents the process cycle controllers and accessory equipment for complete automatic control on process work. The Bristol Co., Waterbury, Conn.

A20 **Rotary Tables.** Pamphlet No. 556 describes three sizes of circular tables which can be tilted through any angle up to 90 degrees, for the accurate drilling and boring of slanting or radial holes in tools or work-pieces. R. Y. Ferner Co., Investment Bldg., Washington, D. C.

A21 **Laboratory Equipment.** Bulletin 1220 describes a thermostatically controlled constant temperature bath of the highest precision, holding temperatures to 0.03°C. Bulletin 1203, a portable temperature-control unit to convert any available container into an accurate constant-temperature bath. Bulletin 1500 describes the Lolag immersion heaters, both plain form and made up in easily applied units for tanks, stills, etc. Bulletin 1510 gives a complete line of laboratory heating apparatus including hot plates, rheostat heaters, flask heaters, muffle furnaces, crucible furnaces and tube furnaces. American Instrument Co., 774 Girard St., N. W., Washington, D. C.

A22 **Vibroscope.** Leaflet describes Models P-2-T and P-3-T vibroscopes for counting the speed of spindles and also observing the behavior of machine parts while in motion. Electrocon Corp., 6 Varick St., New York.

A23 **General Catalog G** issued by the General Radio Co., Cambridge, Mass., is a 173 page index to the many products put out by this company.

A24 **Determinations of Minerals.** Bulletin No. 5 discusses a refractive index determination of minerals. E. Leitz, Inc., 60 East 10th St., New York.

A25 **Micro-Metallograph.** Bulletin No. 3 describes the micro-metallograph simplified model MM-2 with photomicrographic camera. E. Leitz, Inc., 60 East 10th St., New York.

A26 **Micro Analysis of Metals.** Bulletin No. 2 describes the Darkfield Microscope for micro analysis of metals. E. Leitz, Inc., 60 East 10th St., New York.

A27 **Temperature Regulator.** Bulletin No. 53 describes a temperature regulator used for coal fired furnaces, steam, vapor and hot water boilers. Detroit Lubricator Company, Detroit, Mich.

INSTRUMENTS, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

.....

.....

Name.....

Position.....

Firm.....

Street and No.....

City.....State.....

Twin Tank

This type has been popular for a number of years. It comprises two tanks which are independent, but the filling and discharging of which is interlocked mechanically. Some meters operate without, and others by means of, auxiliary power.

The *Hammond* "water weigher" is not a weigher but a volumeter. It requires no auxiliary power: in each tank a large float determines when the flow from the meter inlet at the top center is to be deflected from that tank to the other, but the only work done by each float is to trip a latch, the simultaneous operation of opening and closing the bottom discharge valves being accomplished by means of the head of water above the valve of the full tank, there being at that moment no water above the open valve in the other tank which has completed discharging. The number of discharges is registered by a counting train.

The *Cochrane Corp.'s "Precision"* meter, Figs. 23-15 and -16, is characterized by slender-necked measuring chambers, each with a float almost completely filling the neck, so that the volume of liquid represented by a 1" rise of level around the float is 0.1% of the total volume. The only work done by the floats is to operate a pilot valve: steam power operates the interlocked

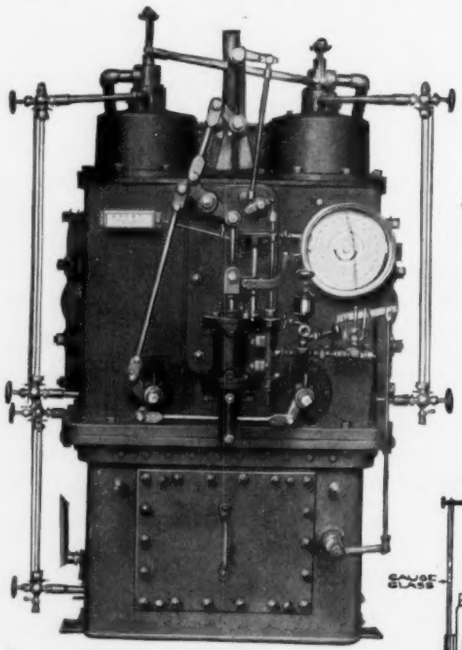


Fig. 23-15

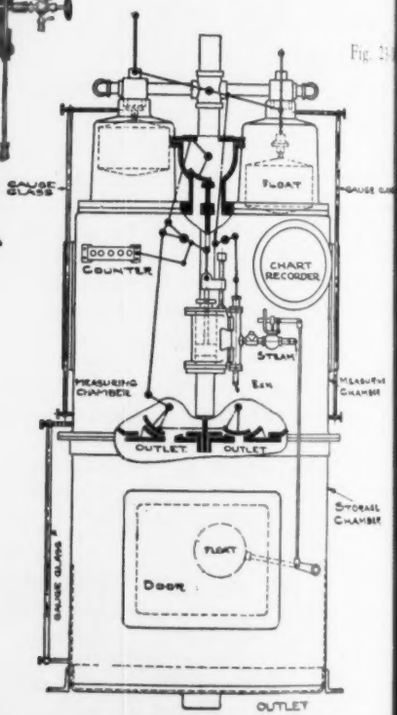


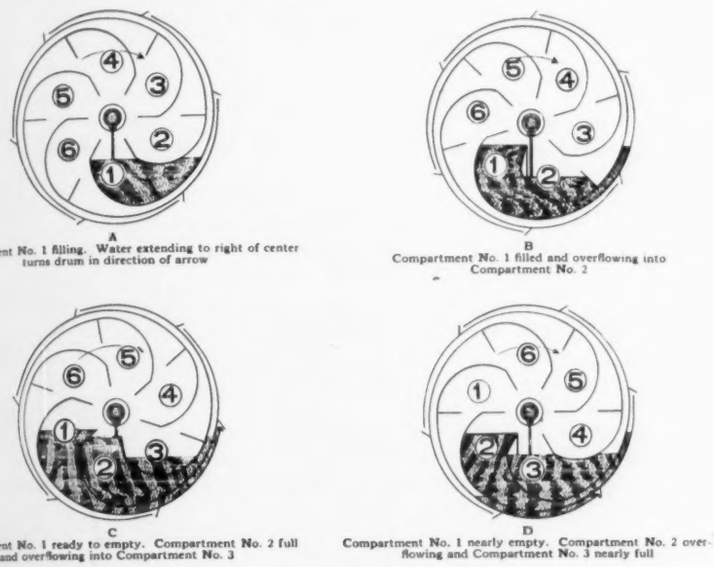
Fig. 23-16

supply and discharge valves. The rate of operation is ordinarily regulated by a float in the outflow chamber, which controls a valve in the steam supply line and prevents throwing of the valves until the liquid level has dropped to a certain point. Where the fluid measured can flow away freely, the outlet chamber, float and throttle valve are unnecessary. The measuring chambers are constructed of cast-iron, steel-plate, copper or other material, according to the liquid to be metered.

The discharge of each two chamberfuls is recorded by the Cochrane Combined Counter and Recorder (see Fig. 23-7 and accompanying text) upon a circular chart by a jog or step in the pen trace, the jogs being grouped in tens for easy counting, while the total number of discharges is registered by a counting train.

Multi-compartment Rotary Drum

"Rotary condensation meters" is the nearly universal designation of these meters in this country, signifying their predominant use and explaining why they are rated in pounds of water per hour. The well-known method of operation is made apparent in Fig. 23-17 but the underlying principle is by no means apparent at a glance. It is said by one maker to be "a combination of gravimetric and volumetric principles," so that variations in the density of the metered liquid are said to be largely compensated for in some cases. We do



A
Compartment No. 1 filling. Water extending to right of center turns drum in direction of arrow

B
Compartment No. 1 filled and overflowing into Compartment No. 2

C
Compartment No. 1 ready to empty. Compartment No. 2 full and overflowing into Compartment No. 3

D
Compartment No. 1 nearly empty. Compartment No. 2 overflowing and Compartment No. 3 nearly full

Fig. 23-17

not doubt that this is true in cases where density varies with temperature and the coefficients of cubical expansion of the liquid and of the drum material are of the same order, but all these instruments appear to us to be volumeters.* Beside condensate, hot and cold water and other liquids of low viscosity not under pressure are satisfactorily metered. The errors in volumetric measurement at normal rate of operation seldom exceed 0.75%.

"*Cadillac*" (Central Station Steam Co.). In addition to the usual "gravity" models, others are regularly made with air-tight housings for use on vacuum heating systems, and these "vacuum types" are suitable also for low pressure heating systems, provided of course that the pressures on the inlet and outlet sides are equalized by means of a balancer. Fig. 23-17 shows the drum of the Cadillac meter. The accuracy guarantee is "within 1% at any rate of flow from zero to full rated capacity." Accuracy is "not affected by variations in bearing friction encountered in service because of the large torque and volumetric measuring principle." Seven sizes are made, with capacities ranging from 250 to 12,000 lb of condensate per hour. The space occupied is approximately 1 ft. cube for the smallest meter and 2 ft. cube for the largest.

The "*Adsco*" (Amer. District Steam Co.) belongs to the same type but among its features one notes that the rotor, made up of "six identical buckets, of proper gauge copper plate, . . . can be taken down, thoroughly cleaned and reassembled in a few minutes. . . . Designed and constructed to . . . prevent racing of rotor should steam under pressure enter meter." This meter operates either at atmospheric pressure or vacuum. Accuracy curves (from factory test records) show a maximum error of $<1\%$ for the two smallest sizes, of 0.1% for the 750-lb/hr. size, and of 0.5% for the larger sizes. Capacities range from 250 to 6000 lb and the corresponding dimensions range from $12\frac{1}{2} \times 12 \times 8$" to $23\frac{1}{2} \times 25\frac{1}{2} \times 21$".

*A true weighing meter would register the weight of liquid passed through *regardless of its density*, but we doubt that a rotary drum meter registering "1000" when a given volume of water at 60°F is passed through would register "13580" when an equal volume of mercury at 60°F is passed through: we believe that it will not register much more than "1000."

INSTRUMENTS BOOK SHELF

Alternating-Current Bridge Methods. B. Hague. Isaac Pitman & Sons, London & New York, 1932. Cloth, 424 pages, 5x8 inches. Price $4.50.

The earlier editions of this work (1923 and 1929) were prepared primarily as a guide to a.c. bridge measurements on communication circuits and apparatus; and the present edition has been amplified by the inclusion of a number of applications of bridge measurements to power circuits, with particular reference to cables.

A logical development of the bridge circuit is carried out in a concise manner with remarkably little "rambling" into the field of other types of instruments and measurements. The author has gone into great detail in the theories, design and construction of apparatus, including capacitances, inductances (pure and "impure") high-frequency resistances and resistance boxes, with a discussion of possible sources of testing current. A very complete study has been made of detectors, with due consideration of the advantages and disadvantages of each type, and the theory of the vibration galvanometer is thoroughly presented. No reference is made to the *asynchronous* dynamometer or galvanometer as a detector instrument. A wide variety of networks is described, each being developed fully from its elementary theories; and the problems of screening and shielding are exhaustively treated. The original book closes with a valuable chapter on the choice of a bridge method, and the precautions to be observed when using it. In this chapter are summarized for use in the laboratory the theoretical and practical information contained in the preceding chapters, so that the investigator may adapt his apparatus and his method to the measurement of inductances, capacitances, effective resistances, power, power factors, etc., under his own particular conditions.

Developments since 1929, mostly in the application of bridge testing to high voltage cables, and dielectric losses in general, are treated in a voluminous appendix, by means of which the work is brought quite up-to-date. An exhaustive list of references extending over nearly a century of bridge measurement is found throughout the work, associated with both the body of the text and the appendix. It is unfortunate that the valuable papers on a.c. bridge methods, recently published by the American Institute of Electrical Engineers (*Transaction A. I. E. E.* Vol. 51, 1932, Pages 198, 202 & 214) appeared just too late for inclusion in the list.

The research or testing engineer equipped with this volume, and having access to the references cited, may proceed with assurance that in any application he desires to make of the bridge circuit to alternating-current measurement he is well abreast of the present state of the art.—Perry A. Borden (4) -B-

Technical Materials, their Properties Defects and Testing. (Die technischen Werkstoffe, Ihre Eigenschaften, Fehler und Prüfung.) Otto Schwarz. Johann Ambrosius Barth Verlag, Leipzig, 1932. Paper, 6¾ x 9¾ inches, 222 pages. Price 24.50 RM.

In a clear and concise manner the author presents the properties of the important materials of construction. While too brief to do complete justice to the title, the space devoted to various subjects conforms well to their relative importance.

Mechanical properties are defined and described in a brief but adequate manner. Then, even more briefly the concepts of physical metallurgy are presented.

The body of the book deals systematically with the properties of specific materials. Non-metallic materials are briefly mentioned. The book closes with a description of machines and instruments for testing materials.

The treatment is quite up-to-date. Nothing of only historical interest is described. While some of the data are probably new, the book contains little which has not been previously known. It should prove to be a good reference book. H. W. RUSSELL (3.1)-B-

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Handbook of Industrial Temperature and Humidity Measurement and Control. M. F. BÉHAR. Instruments Publishing Co., Pittsburgh, 1932. Cloth, 6¼ x 9½ inches, pages 113-420. Price $4.00.

This book comprises parts 2 and 3 of the comprehensive "Manual of Instrumentation." Part one, "The Fundamentals of Instrumentation," was brought out earlier in the year.

In this text Mr. Béhar has kept constantly in mind the object of providing a practical handbook for industrial use. Accordingly, the theoretical aspects of the subjects are presented very simply and rather briefly. The author has assembled a large amount of valuable information, and has put it in readily usable form. The Handbook is well printed, on good paper, the cuts are clear, and the binding permits the volume to lie open on the desk for reference. The reviewer believes that this Handbook will be found to be very useful and suggestive by anyone who has to do with temperature and humidity measurement and control.

The Handbook contains 7 chapters on temperature, 4 on humidity and 9 appendices. After presenting some general ideas on temperature, the subjects of thermometers, thermoelectric, radiation and optical pyrometers, recorders, automatic temperature control, and control instruments and accessories are discussed in detail. There is a careful classification of types of the different classes some of the more important makers are listed, and their instruments described, many cuts being used. The methods of use and precautions in use are also given. These descriptions seem to have been brought remarkably well up to date.

The section on humidity presents first general data, and the importance of humidity, second, information in regard to humidity measurement and charts, third, humidity and aerological measuring instruments, and fourth, the automatic control of humidity.

The appendices include temperature conversion tables, data on the checking of pyrometer installations, thermocouple constants for practical couples, psychrometric and humidity tables, etc., etc. S. L. GOODALE (2.06 & 2.08)-B-

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Testing Radio Sets. By J. H. REYNER. Chapman & Hall, Ltd., London. 207 pages. Cloth, 8¾ x 5½ inches. Price 10 shillings, 6 pence.

A revised edition of Mr. Reyner's book on testing radio receivers has just reached this country. The author's position in the English radio world as consulting radio engineer and as technical editor of two radio magazines: *Amateur Wireless* and *Wireless Magazine*, gives his discussion of testing methods and test equipment the weight of authority.

He goes back to fundamentals of simple radio circuits, their operation and possible faults, giving the best methods for locating trouble, and stressing the necessity of system in the test method. A carefully written description of the meters and other instruments used in test work as applied to these simple circuits is an important part of the volume, and the radio amateur will find detailed information on this subject as well as their use in practical test work. A clear and lucid style helps the amateur over the rough spots.

From the radio service-man's point of view it is to be regretted that more space was not given to the a.c. receiver than a short chapter. The three-circuit regenerative type of battery-operated set, of which there are still thousands in England, has very nearly reached the point of extinction in this country; and it is this type around which the author has written his practical demonstration of fault finding, throughout the greater part of the book.
V. S. CHURCH (5.1)-B-

7. Liquid Displacement Meters

(a) The Piston and Disk Controversy

(This Art. appeared in the December issue of INSTRUMENTS.)

(b) Characteristics

Capacities. This class of meters includes all sizes required for industrial positive metering purposes—from fuel meters for automotive vehicle engines to oil meters for loading tank ships. Data appear below as part of most descriptions.

Liquids. Cleanliness and freedom from gas are essential. The use of strainers, traps, etc. to assure these properties is imperative. Beside the numerous meters for water and for petroleum products, a few are suitable for many other liquids, including milk, syrups, lacquers, chemicals, etc., contamination by lubricants being assured against since working parts are lubricated by the metered liquid and the register is generally under a lower pressure so that the register drive shaft lubricant, if any, is unlikely to enter the stream. The temperature of the metered liquid is important in many cases: for example there are both hot water and cold water meters, made of different materials and not interchangeable. Also, a change of state causing considerable errors, liquids should reach the metering point well below their boiling point for the inlet pressure, especially when the flow rate is near the capacity of the meter and the consequent pressure drop is such that part of the liquid would be vaporized inside the meter.

Readings and Records. All liquid displacement meters register total quantity; many have an additional sub-total counter or dial which may be reset by hand. The large dials of gasoline dispensing meters, too familiar to be dwelt upon, are mentioned to point out the possibility of specifying them for industrial applications where readability is desirable. Electrical remote-reading systems are available as standard equipment with at least one make; as optional or special equipment with others. Continuous indication of instantaneous rate-of-flow is given by a tachometric attachment furnished regularly on at least one standard meter, optionally on some others. Recording attachments furnishing flow rate charts are not standard equipment on any liquid displacement meters at this writing, but the demand for flow recording instruments with positive displacement primary elements will cause such devices to become available before long.

Degree of Positiveness. This characteristic depends not only upon the type but upon the workmanship. Workmanship need not be discussed here and must not be discussed under descriptions of commercial meters in the following pages. Concerning the dependence of degree of positiveness on type, most ring-sealed reciprocating piston meters in good condition start registering "accurately" (<2% error) at a barely perceptible flow when metering oils and at less than 0.3% of capacity flow when metering aviation gasolines. On the other hand, most nutating-disk meters—even when new—do not register at all at extremely low flows, and start registering "accurately" (<2% error) at from 1% to 5% of capacity flow, depending more on the metered liquid than on the particular make.

But not all piston meters are of the elastically-sealed reciprocating piston type with pressure-sealed sliding (slide or rotary) valves. Oscillating and rotary piston types (often overlooked by reason of their comparative scarcity and their being confused with ring-sealed types) depend upon clearances, somewhat as do the many nutating disk meters.

Cost, while not an engineering characteristic, is nevertheless a characteristic to be considered. A nutating-disk meter costs but a fraction of what a piston meter does, size for size.

Size and Weight. These vary within each type, with the particular make, except that the disk type is smaller and lighter than others of equal capacity, and that all makes of disk meters are much alike in these respects.

Pulsating or Intermittent Flows do not seriously impair accuracy of registration except when either a dribble or a flow in excess of capacity is of fairly long duration and recurs frequently.

Pressure-loss varies with the different designs and makes within each type, so that no general statement can be made concerning each type, except that in general, the various makes of nutating-disk meters of one size for a given liquid show absorption curves that agree much more closely among themselves than do the curves of different makes of piston meters of one capacity. This is a natural consequence of the fact that all makes of nutating-disk cold water meters of a given size, for example, are much alike (despite manufacturers' emphasis of exclusive features) while the various piston meters of the same size and for the same purpose differ from one another in many obvious and essential features.

(c) Reciprocating Piston Types

The A.S.M.E.'s brief official classification lumps all piston meters under the one type designation. Actually, the commercially available piston meters belong to several types. Even under the heading of "reciprocating piston" meters there appear to be several types rather than one distinctive type.

Single-piston—Crankless—Valves Thrown at End of Stroke

This type seems to be the original form of "piston meter." The *Kennedy* meter, its oldest example, invented in 1852, has a four-way cock thrown abruptly at the end of each stroke by means of a weighted lever; another interesting feature is that the register does not count strokes but actually measures the piston travel at each stroke by means of two fine-tooth racks carried by the piston rod.

The Illinois Electric Fuel Meter (Illinois Motive Equipment Co.) may be mentioned at this point. Its displacement primary is installed on or near the engine; its register on the vehicle's (or airship's or motorboat's) instrument board. Its maximum capacity is nearly 20 gals. per hour but its registration curve is said to be a straight line as far down as 1 pint per hour. The required electrical energy, negligibly small, is obtained from the vehicle's storage battery.

The *Bassler* (American Liquid Meter Co.) represents a new form of the old single-piston crankless type. It was designed especially for petroleum products. Figs. 23-21 and -22 are almost self-explanatory: The piston throws one of the two main valves at each end of its stroke. The pilot sleeve valve, actuated by the spiral shaft, serves to carry the main valves past dead-center position. The spiral shaft also operates the register (upper left). The diagram and the photograph do not correspond in every respect, the former showing the earlier design and the latter a 1933 model with longitudinal instead of helicoidal sleeve valve ports. Sizes range from 1" to 6", capacities from 2-25

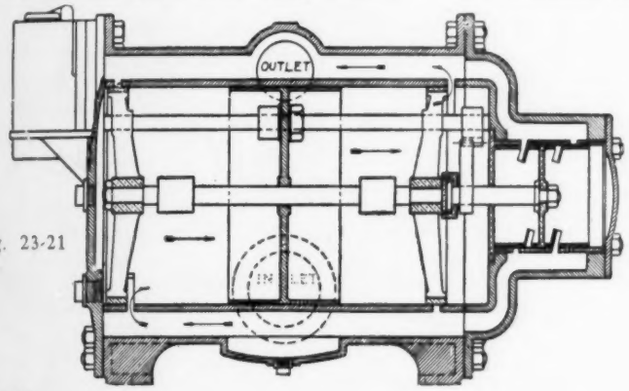
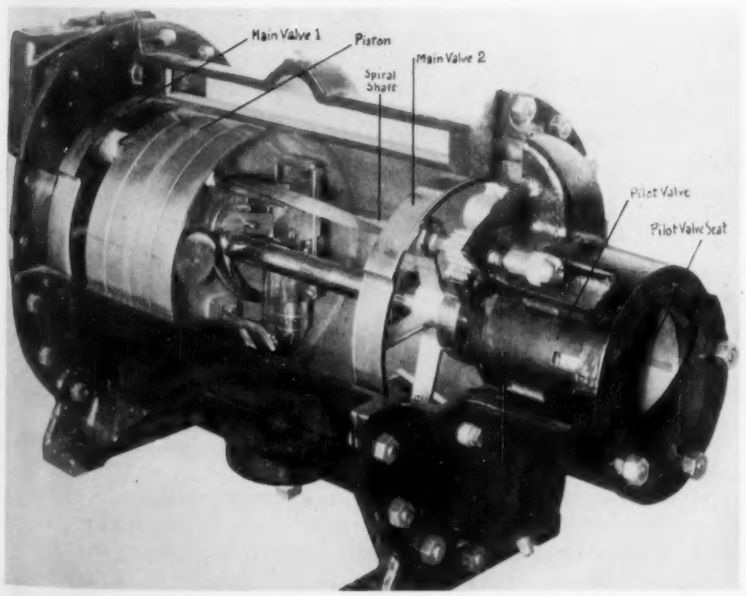


Fig. 23-21

Fig. 23-22



NEW INSTRUMENTS

Write Information Section, Instruments Publishing Company, for additional Information.

Direct-Reading Relative Humidity Recorder

The Bristol Co.

THIS novel instrument, the Humidigraph, utilizes as sensitive element a unique hygroscopic device that essentially consists of sensitive wood fibres built up on a nickeled wire screen wound in the form of a spiral. Changes in the relative humidity cause the free end to revolve about the axis of the spiral. This rotation is transferred by means of a simple linkage to the pen arm. Hairs, springs, rollers, and other delicate parts are eliminated. A special aging and treating of the wood fibres assures the maintenance of the initial calibration, as well as dependability.

The Humidigraph finds wide application in printing plants, railroad passenger and refrigerator cars, artificial ice plants, bakeries, celluloid, confectionery, drug, explosive, fruit storage and gelatin plants, incubators, lacquer and lumber seasoning rooms, paper, rubber and textile mills, in the curing and storing of tobacco, etc.

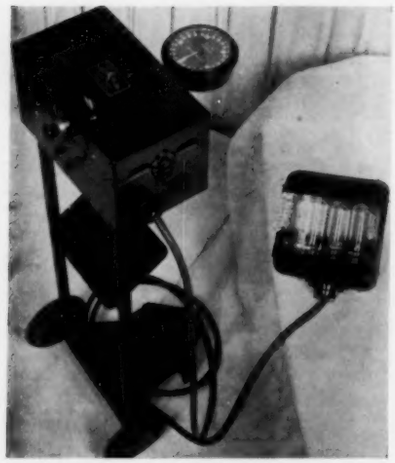
The Humidigraph is made in 4" and 8" size portable or wall recorders, with 24-hour or 7-day charts. The larger size comes also in a two-pen model, recording temperature as well as relative humidity.

◆ ◆ ◆

Improved Stroboscope

Electrocon Corp.

ESPECIALLY adapted for measuring the speed of spindles in textile mills and observing the effects of rapid rotations or reciprocations, this new model Vibroscope is built into a strong metal box supplied either on a wheel chassis or in a portable case. The box contains an accurately governed variable-speed motor and the electrical parts for flashing the neon tubes. The hand lamp is strapped to a shelf on the chassis for transportation, and held in the operator's hand in use. A high-grade tachometer is mounted on the motor shaft when the instrument



(as illustrated) is to be used for speed measurement. The speed range of the motor on the standard models is from 1200 to 8000 r.p.m. Spindle speeds of much higher frequencies can be accurately determined. For instance, a spindle running at 12000 r.p.m. will appear stationary when the lamp is flashed at 6000. Motors with speed range from 200 to 8000 r.p.m. can be supplied.

The standard instruments operate from 100-120 volts a.-c. supply. They can be converted for d.c. operation where a.c. is not available. 2 or 3 neon tubes are mounted in the hand lamp: 2-tube Model P-2-T gives ample light, but the additional light of the P-3-T is sometimes valuable when it is desired to make a close study of moving parts. The light flashes are of extremely short duration, which makes it possible to view moving parts in close detail.

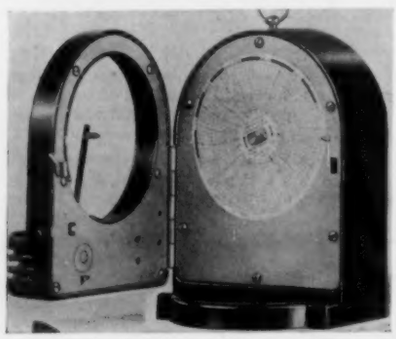
◆ ◆ ◆

Portable Temperature and Operation Recorders

Practical Instrument Co.

WEIGHING and costing much less than a typewriter, this new design of recorder has an unbreakable face, plated and rust-proof metal parts, non-clogging nickel-silver pen that never is in the way, and no loose or chained parts. The sturdy 36-hour chart-drive is wound, set and regulated from the back of the instrument without opening the case.

The temperature recorder comes in two ranges, 30 to 60 and 60 to 90 deg. F. The operation recorder can be used on d.c. or a.c. motors up to ½ h.-p., 110-220 volts, any cycle. Charts are 4″ in diameter, 24-hour period.



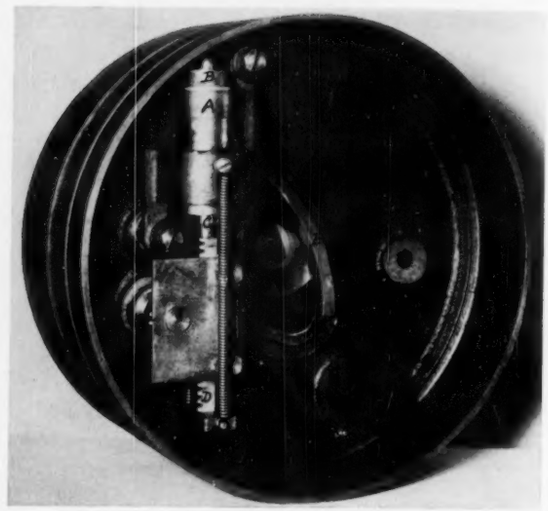


Fig. 23-23

g.p.m. to 125-1250 g.p.m. Maximum working pressures, 25, 125 and 250 lb. One patented feature of this meter seems to deserve mention, being a thermostatic compensator, Fig. 23-23, the action of which is described as follows:

"Cylinder *A* is filled through cap *B* with the liquid to be metered (or liquid with similar co-efficient of expansion). Temperature of metered liquid is transmitted to liquid within cylinder *A*, causing it to expand or contract proportionately. This movement is transmitted to plunger *C* and rack *D* which in turn operate helical arm *E* which intercepts the valve control. In other words, this arm permits the piston to compensate for the expansion or contraction of the liquid metered and causes the meter to register liquid as of 60°F. or any other desired basis of measure."

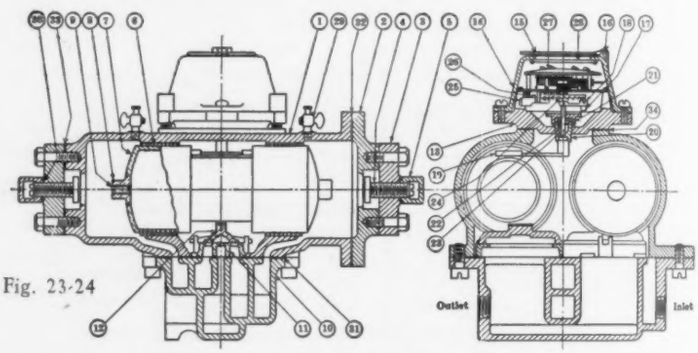


Fig. 23-24

Twin-plunger—Crankless—Valves Thrown at End of Stroke

This type, like the preceding, has a comparatively long history. It is exemplified by the *Worthington* "duplex piston" meter, Fig. 23-24, which is of the same design (but of different materials) for hot water, crude oil, petroleum, naphtha, etc. The slide valves 12 are thrown by the pistons at the end of each stroke. A minimum differential of 5 lb per sq. in. is required to secure the full rating for each size of oil meter; for hot water meters the loss of head at top rating varies from 3 lb for the ⅝″ size to nearly 8 lb for the 6″ size. Air cocks 29 are for venting any gas which may collect when metering hydrocarbons. Adjustable tappets 4 serve to regulate stroke length when calibrating. This ease of adjustment contributes to the attainable accuracy and compensates largely at normal flow for the inevitable increase of slippage with length of service. (Note that there are no sealing rings.) High-pressure models are available, from 500 lb in the smaller sizes to 250 lb in the largest.

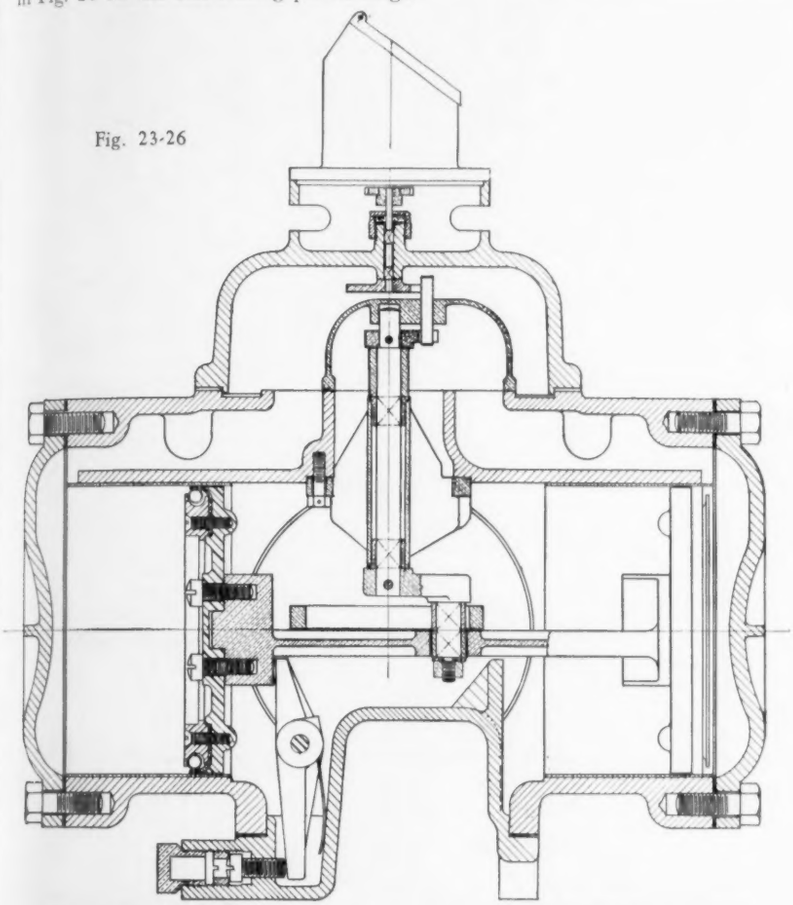
Cross-piston—"Crankless."

This type has the equivalent of a conventional crank, but no connecting rods, one object being to reduce the number of parts. It is of recent origin, and had not been produced in great numbers until 1932. The *Pittsburgh Oil and Gasoline Meter** (Pittsburgh Equitable Meter Co.) employs a sort of Scotch yoke to rotate the central shaft which carries the rotary valve and operates the register. Fig. 23-26 is a vertical section of the 2″ meter, and Fig. 23-27 is a sketchy schematic diagram showing one set of pistons and the yoke of the other set as viewed looking down. Note the clearance between the slots and the pin: it does not affect the rotation of the shaft, which always makes one revolution

*In sizes 2″ or greater. The 1″ size has a conventional connecting rod and crankshaft.

per complete cycle as shown by the arrows (direction D D of the yokes produces clockwise rotation) but it permits adjusting the length of stroke of *each* set of pistons—which is done with the micrometer screw, bottom left, Fig. 23-26. The 2″ size here illustrated has a maximum capacity of 120 g.p.m. and will meter a flow of 1 g.p.m. with an error of $<0.4\%$. The error at full capacity flow is $<1\%$. It weighs 135 lb in the iron case (150 lb max. pressure) and 65 lb in the aluminum case (10 lb max. pressure). The 3″ size weighs 225 or 110 lb depending on case, and its stated capacity range is 5 to 300 g.p.m. but it shows negligible errors at 1 g.p.m. when kept in good condition. Note in Fig. 23-26 the self-sealing piston rings.

Fig. 23-26



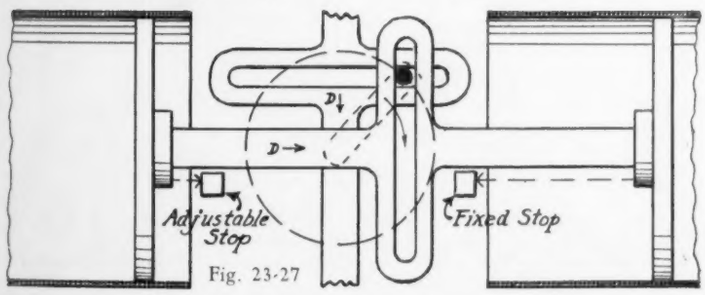


Fig. 23-27

The *Badger G-P* (Badger Meter Mfg. Co.) follows the same scheme of crossed cylinders and central shaft, but the pistons drive the shaft by means of a cam. Fig. 23-28 is a vertical section and Fig. 23-29 is a horizontal section. The cam is so shaped as to cause each pair of pistons to "dwell motionless" at the end of each stroke, which results in uniform discharge from the meter and also permits considerable overlap of valve over port since the cut-off and admission occur during the "dwell" of one-eighth shaft revolution.

An interesting feature is the combination of absence of sealing rings, and looseness of pistons in cylinders, with a device for keeping the pressure on the side of each piston open to the outlet equal to the pressure on the side open to the cam case. This device is said to return to the supply line a volume of fluid equal to the leakage caused by pressure differences which may build up.

Re-designed Magnetic Relays

Ward Leonard Electric Co.

IN the latest design of Midget Magnetic Relays for remote control, a new molded base provides more rigid mounting of contacts and binding posts. A newly designed armature improves the magnetic circuit and alignment of contacts with reduced energy consumption.

These relays can be furnished in single and double pole, single and double throw and various arrangements of contacts and terminal connections for a.c. and d.c. up to 110 volts.

◆ ◆ ◆

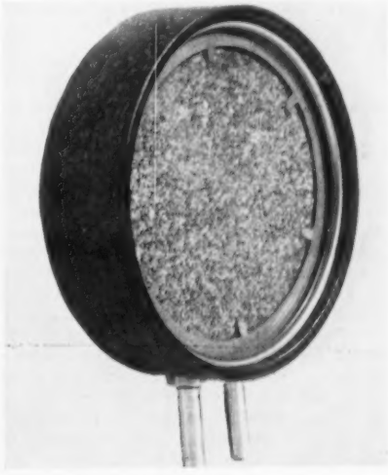
Self-generating Dry-disk Photoelectric Cell

J. Thos. Rhamstine

AN improved photoelectric cell for general application and service in the laboratory, commercial and industrial fields, the Rhamstine "Electronic" cell is of the dry disk type and transforms light energy directly into electrical energy. Tested on a d.c. milliameter reading 0 to 10 ma., the cell generated from 5 to 7 ma. in direct sunlight. The current is always directly proportional to the light intensity.

Exposure to strong light or any climatic condition has no effect on the cell's efficiency. It generates electrical energy at no expense to the materials used in its construction, is of apparently unlimited life, and with reasonable care should last indefinitely.

The cell measures 2¾″ diam. and 1″ thick. It is equipped with two connection prongs which fit the standard UX radio tube socket.

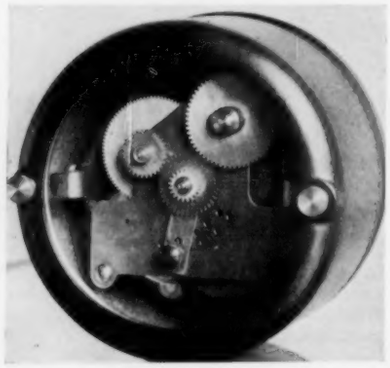


New Synchropulse Timer

Eagle Signal Corp.

DESIGNED to close a circuit repeatedly for predetermined intervals with definite periods of time between closures, this new Synchropulse Timer is a timing device or interrupter which combines, it is said, flexibility of timing and a variable period of contact closure with compact, rugged construction. Among its applications are the periodical reversal or intermittent operation of motors, the operation of electromagnets and the operation of visible or audible signals. The timer illustrated is designed for reversing laundry washers equipped with reversible motor drive.

The new timer consists essentially of a low-speed self-starting synchronous motor driving a set of cams through a gear train, the cams in turn actuating the timer contacts. The mechanism is mounted on a Bakelite base and protected by an aluminum cover with a glass front. The unit, 4⅝" in diameter, is designed for panel or switchboard mounting, connections to the timer being made by means of studs which extend through the base.



The standard timer is equipped with 5 change gears for adjusting its cycle, which is readily accomplished without tools. The gears provide one revolution of the cam shaft or one cycle of operation in 20, 25, 30, 45 and 60 secs. Other gears are available for longer cycles. Contacts are of coin silver and conservatively rated at 2 amps. 110 volts a.c.

◈ ◈ ◈

Resetting High Speed Counter

Veeder-Root, Inc.

THERE has been a demand for a resetting counter that would subtract when running in the opposite direction, that would operate at high speed in either and that would be positively jump-proof. This new instrument has been designed to meet these requirements, being a 5-figure small and compact counter which, when in operation, is exactly the same as a locked wheel counter. It resets to zero by one turn of a wing nut. Once resetting is started it must be completed before the counter can again register. This assures authentic registration. The direct drive models operate accurately up to 8000 counts per min., the revolution type up to 2000. Overall dimensions are 4x1.4x1.3 in.

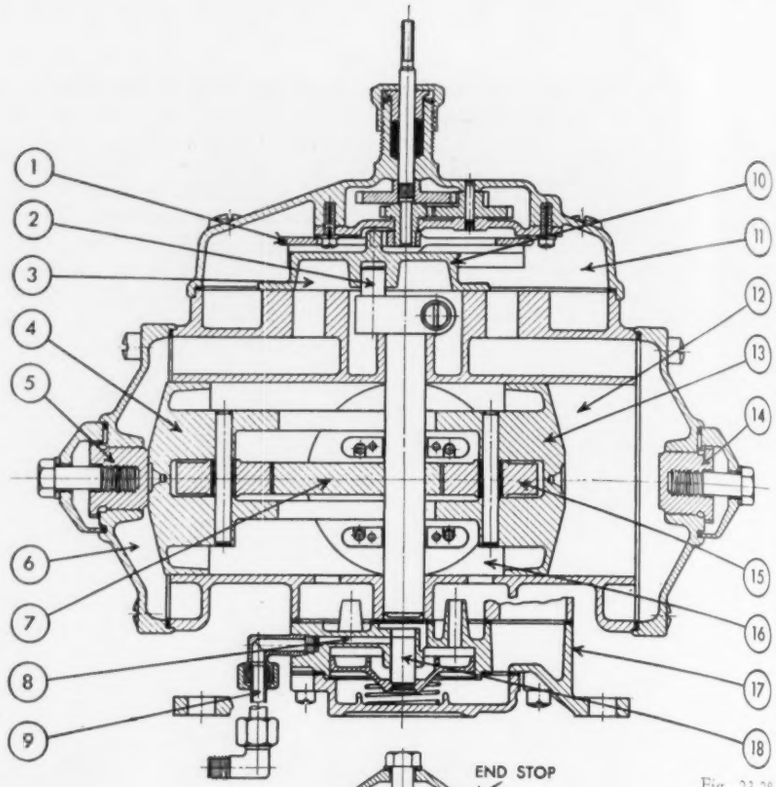


Fig. 23-28

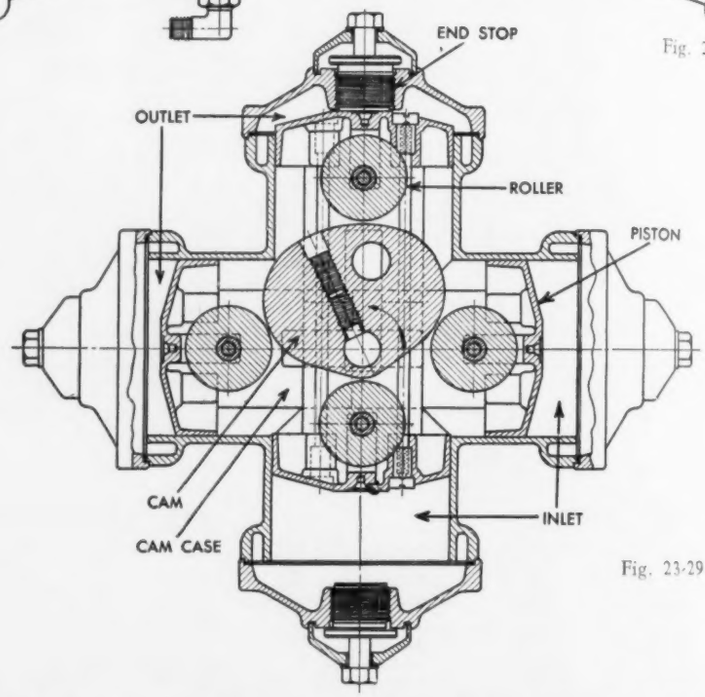


Fig. 23-29

The liquid enters cylinder 12 from inlet chamber 11 and moves pistons 13 and 4 until they reach stop 5. At this end position (shown in Fig. 23-28) the piston remains at rest for one-eighth of the cycle. At the beginning of this "dwell" period piston 13 is open to inlet 11 and piston 4 to outlet 3 (as in the diagram). Toward the end of the dwell period valve 10 closes inlet and outlet to pistons 13 and 4 respectively, and, as the valve is moved in a uniform motion by pin 2 and is prevented from turning by guide 1, it slowly opens the inlet for piston 4 and at the same time also opens the outlet for piston 13 which now forces liquid through outlet 3, both pistons being moved toward stop 14 by the liquid which enters cylinder 6. A similar action takes place at a 90° interval in the two adjoining pistons and cylinders (not shown).

"The pistons are loose fitted to reduce friction to a minimum. The liquid is prevented from leaking between piston and cylinder wall by automatic regulator 17 which maintains an equality of pressures between outlet chamber 3 and cam case 16. The balancing of pressures is accomplished by plunger 18 which permits the liquid at certain moments to flow through passage 8 and then through return line 9 back to the pump or tank without being measured by the meter. The accuracy is not affected by variations of viscosity, specific gravity and pressure of the liquid," assert the makers.

This meter is regularly made in sizes from ½" (8 g.p.m.) to 2" (125 g.p.m.). The registers, driven by the shaft at the top, are of large vertical dial style, for dispensing service.

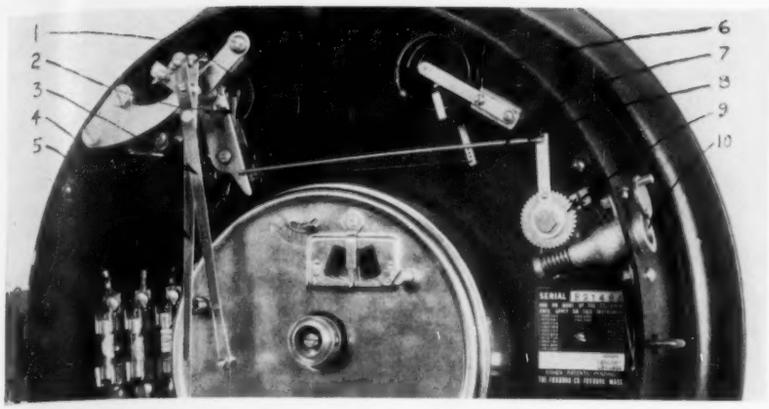


Fig. 1

Electric Contact Type Recorder-Controllers

The Foxboro Company

FIRST ANNOUNCED last spring, this new line of recorder-controllers has since then been more highly developed, and successful installations have been made on applications calling for two-pen instruments, various types of relays, different valve-operating devices, etc. As a result of this diversified practical experience, several design features have been standardized while affording sufficient "flexibility" to meet many unusual process control problems.

The distinctive feature of this line consists of the use of *rotating contacts* (whence the name "Rotax") which will, it is claimed, "out-perform any other type of contacts" employed in automatic control instruments. In addition, these contacts afford obvious advantages such as easy setting from outside the case, unrestricted pen movement over the entire range, a simple spacing arrangement whereby the differential may be adjusted from the equivalent of the total scale length to the minimum of 1% thereof, a "commutator and brush" action which keeps contact surfaces clean and reduces arcing, etc.

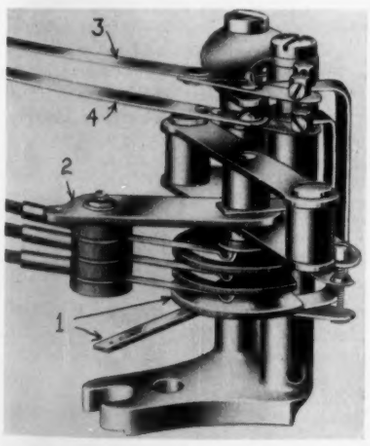


Fig. 2

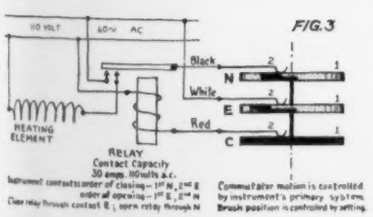


Fig. 3

Fig. 1 shows the principal elements of a "Rotax" recorder-controller. (This particular instrument is a temperature recorder-controller, and the pressure-spring 6 terminates a thermal system, but the primary system of a Rotax may be one suitable for pressure, humidity, flow or liquid level.) Pressure-spring 6, through phosphor-bronze link 7, causes rotation of both pen-arm 3 and contact disks 1. Contact brush assembly 2 is fixed in relation to index arm 4. The setting of both 2 and 4 is effected by turning a key inserted at 10, causing rotation of worm wheel 9 and movement of link 8.

Parts 1 to 4 are shown in greater detail in Fig. 2. The commutator contact assembly 2, complete with contact brushes, is pivoted on the same axis of rotation as pen arm 3 but it is connected to index arm 4. When the outside setting arrangement 10 is operated, the entire brush assembly swings around its axis of rotation.

The commutator disk assembly 1 is rotated as a unit with pen-arm 3 by the pressure or temperature system. The lower commutator disk is the common contact and its entire contact surface is heavy rolled silver on gilding bronze. The center and top commutator disks are Bakelite with metallic inserts set flush with the Bakelite surface. This insures smooth, free operation of each brush from the Bakelite to the metallic surface. The inserts are platinum faced over bronze and resist oxidation and arcing. The brushes have platinum-iridium contact surfaces. The entire contact assembly is subjected to a breakdown test of 1170 volts.

In Fig. 2 the upper brush is shown on a metallic segment while the middle one is on the Bakelite surface. The contact surfaces of brushes are in the same vertical plane and the gap between "on" and "off" can be readily seen by the respective positions of the edges of the metallic inserts.

The working capacity of the contacts is 0.2 amp. maximum at 110 volts a.c. or d.c. and 0.1 amp. max. at 220 volts a.c. or d.c. This capacity should not be exceeded when the contacts are used for visual or audible signals. The makers have provided a fuse box (No. 5 in Fig. 1) with 1 amp. fuses as standard equipment, positively preventing damage to the contacts, but they recommend that a positive lockup relay be used and that the instrument contacts carry only a negligible relay load.

The circuit is specified as a three-wire system, using a simple, positive lockup type of relay. A single circuit contact system with a simple relay of the non-lockup type is not satisfactory for the reason that the relay will chatter when the contact is made or broken.

Fig. 3 shows a simple wiring diagram for a heating circuit. All three brushes are in contact with their respective segments, while the temperature is below the control point. The relay is actuated and closes the circuit to the heating unit to raise the temperature. When the control point is reached the center circuit *E* is broken but the relay is still locked up through circuit *N* and the heating circuit remains closed until the temperature reaches the point when the brush on the upper disk or circuit *N* leaves the metallic segment. At that time the *N* circuit is opened and the relay unlocked, and the circuit to the heating unit is opened. The temperature then may start to decrease and cause the brush again to contact the segment in circuit *N* but nothing happens until the temperature gets to a point where the brush engages the segment in circuit *E*. The relay magnet is again energized, closing the heating coil circuit through the operation of the relay. This arrangement insures positive action of the relay in either direction, prevents unnecessary arcing and chattering when the contacts are closely spaced, and gives an excellent mode of control.

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Coil Type Rheostat

Ward Leonard Electric Co.

FOR applications requiring a rheostat with a fine continuous adjustment, the extremely shallow depth of this new device is a distinct advantage where space is limited. The coiled wire resistance element has a low temperature coefficient of resistivity. The plate and wire are coated with a powdered glassy enamel and fired at red heat, to prevent shifting of the wire. The dead shaft, completely insulated from the 2 contact levers, makes the rheostat adaptable for

steel panel mounting without the use of insulating bushings or washers. A ventilated enclosure can be provided for protection of live parts. The rheostat is obtainable in values of resistance from 1 to 350 ohms. It will dissipate 70 watts continuously with a temperature rise not exceeding 250° C. which is within the limits specified by Underwriters' Laboratories.

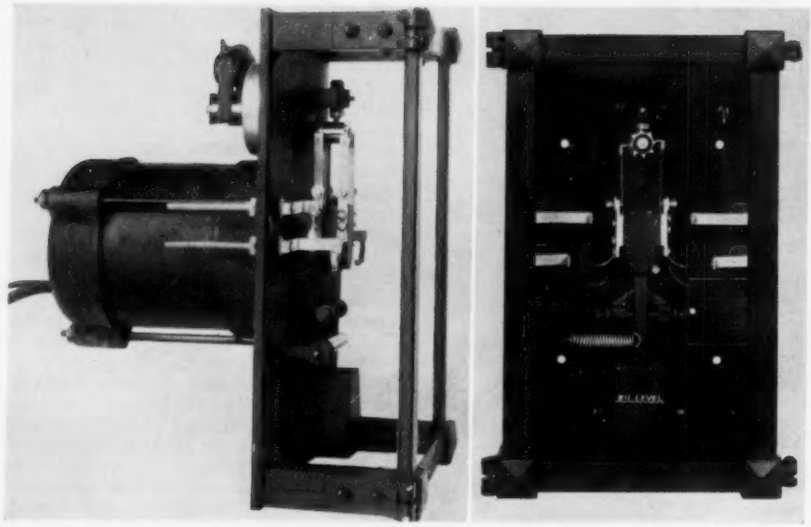

Fig. 1

Rheostatic Regulator With High Speed Features

By W. H. Turner*

SIMPLICITY, sturdiness, fast action when necessary, and extremely low maintenance characterize the new FA-4 rheostatic generator voltage regulator. Particularly adapted to generators with exciters whose fields are separately excited from constant voltage pilot exciters, it can be used where the field current of the main exciter is too heavy for the vibrating type of regulator or where the vibrating type is not desired.

As long as the a.-c. voltage is within 0.5% of normal, the regulator equipment remains dormant except that a tiny synchronous motor rotates the notching cam contact and the center disk contact. Upon *slight* voltage changes, the regulator simply operates the motorized exciter field rheostat; upon voltage changes of 2% or more, a large change in exciter voltage is obtained by the action of high-speed relays commanded by the regulator. The raising relay can impose full field upon the main exciter; the lowering relay inserts a large block of resistance in the main exciter field. Simultaneously with the action of either high-speed relay, the exciter field rheostat operates to assume the new position for the changed load condition. The bridge type rheostat makes it possible to obtain a zero or slightly negative voltage across the collector rings. This is desirable in case of loss of load condition of water-driven generators; it allows the maximum amount of lagging kv-a. to be supplied by a synchronous condenser.

The regulator equipment consists of three parts: the control head (Fig. 1); the motor-operated exciter field rheostat (Fig. 2) and the high-speed relays (Fig. 3).

The control head which may be mounted as a unit upon the switchboard panel consists mainly of a 3-phase element called a torque motor, the rotor of which is stalled and whose torque is opposed by a helical spring (Figs. 1 and 4). The 3-phase stator with external resistors and 3-plate adjusting rheostat is connected to the secondaries of two open delta potential transformers so that an average of the 3 phase voltages is regulated. The rotor consists of a hollow cast iron cylinder mounted on a ball-bearing supported steel shaft which carries an insulated lever arm with two pairs of spring contacts (front and back) and a dampening paddle. A tiny synchronous motor continuously drives the center cam contact and disk contact at 4 r.p.m. This prevents contact sticking and keeps the contact surface clean. The shape of the cam contact, together with the oil well, prevents over-shooting of the rheostat and regulator hunting. The control head commands all action, varying from no action when the a.-c. voltage is normal to full action of high-speed relay and motor-operated rheostat during disturbances.

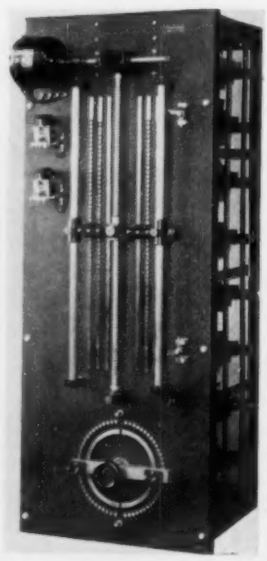

Fig. 2

The motor-operated exciter field rheostats (Fig. 2) have 200 steps so proportioned that the main exciter voltage does not change more than 0.75% per step over the entire operating range.

Bridge type connections (Fig. 4) are used whenever the exciter field is separately excited. This type is capable of changing the main exciter voltage over an extremely wide range without using high resistance wire as in the series type. The sections of resistance are selected to keep the losses low and to obtain equal volts per step throughout the entire operating exciter voltage range. The bridge is made by two permanent sections of resistance and two variable sections, beside the two field reducing sections which are only inserted during over-voltage conditions. The arms of the variable sections are mechanically connected but electrically separate and considered as one arm. When the arm or lever is at the top, maximum excitation is on the main exciter field. When the arm is at the extreme "down" position, a slight reverse current is imposed on the main field so that residual is overcome. This is readily understood if we apply some resistance values to the bridge rheostat in the elementary wiring diagram. Assume the permanent sections L1-38 and L2-3A are 100 ohms each, and that each variable section across which the normally open contacts "Y" are connected, measure a maximum of 120 ohms.

To an operator, the bridge rheostat is controlled the same as an ordinary rheostat but the range in obtainable exciter volts is much greater and the volt-button curve is practically a straight line.

The high-speed relays (Fig. 3) are mounted on a panel which is usually placed above the motor-operated exciter rheostat panel. The contacts of the "raise" relay are normally open; when closed they put full excitation on the main exciter field by short circuiting the variable sections of the exciter field rheostat. The contacts of the "lower" relay are normally closed, but when energized insert the field reducing sections in the main exciter field, thus causing a rapid decay of exciter voltage. The cores of these relays are laminated and the moving parts are very light so that fast action is obtained whenever the "raise" or "lower" relay is energized by the back contacts of the regulator. The blowout coil in series with each of the relay contacts make it possible to control heavy field currents successfully. Since these relays only operate upon sudden changes in a.-c. voltage, maintenance is reduced to a minimum.

The regulator is easily put in service or taken out of service by a turn button type transfer switch, which may be thrown when neither set of contacts is in engagement. Pilot lamps can be added to indicate this condition, when the regulator is located rather remote from the operator.

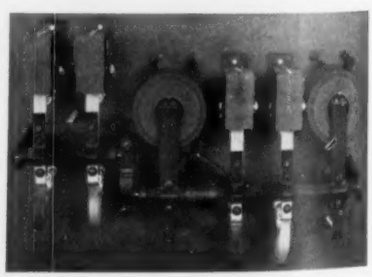

Fig. 3

*Voltage Regulator Dept., General Electric Co.

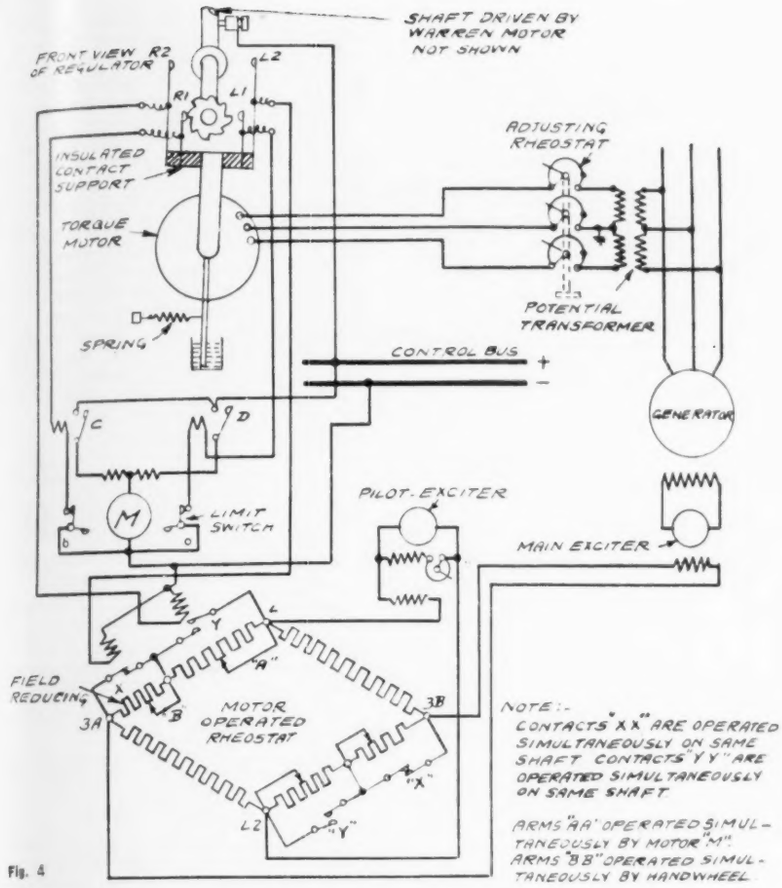

Fig. 4

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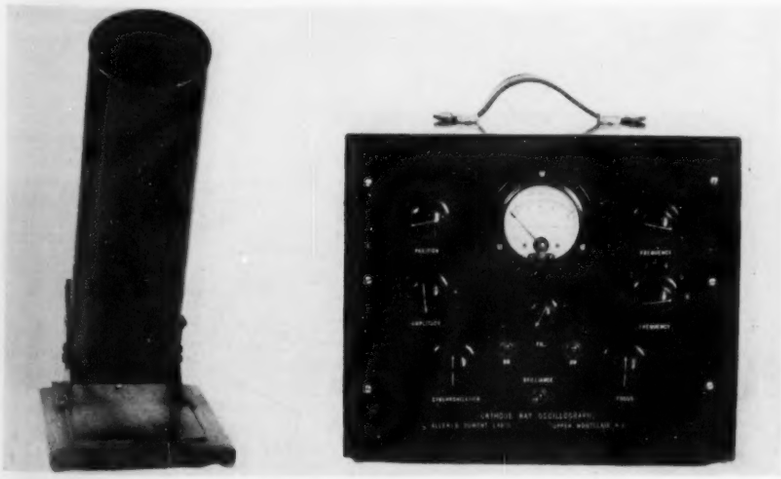
Portable Cathode Ray Oscillograph

Allen B. Du Mont Laboratories

FOR the first time, it is said, a complete cathode ray oscillograph is offered which is readily portable and simple to operate. It has been designed to be used for various factory checks now done by other methods which require more time and do not give as complete information.

The outfit consists of a power supply, sweep circuit and shielded cathode ray tube holder, together with the necessary tube equipment which includes a regulator tube, rectifier tube, mercury vapor discharge tube and a standard Du Mont Cathode Ray Tube. All the necessary voltages are obtained from the standard 60 cycles mains.

Means are provided on the power supply for adjustment of the filament current, focusing electrode and accelerating voltage. A meter is provided to insure against excess current to the filament. The sweep circuit has controls for amplitude, position of the wave and synchronization. The sweep frequency range is from 10 to 15,000 cycles. All necessary cables and plugs come with the equipment.



Bi-metallic Thermostat

Detroit Lubricator Co.

QUICK make and break is obtained in the operation of this new room-temperature device, by means of a permanent magnet said to prevent corrosion or sticking at the contacts. "No. 454 Genuine Detroit" thermostat is regularly supplied to control temperature at any setting between 55° and 85° F. The differential is said to be very close under normal conditions.

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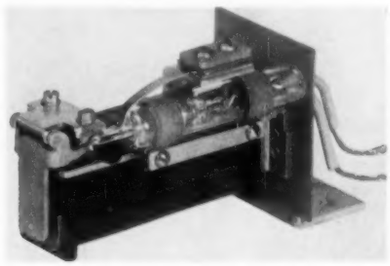
Vacuum Contacting A.C. Relay

Automatic Electric Co.

THIS new device is a standard a.c. relay long used in automatic telephone apparatus, but modified to accommodate a vacuum contactor. The



contactor can open and close circuits carrying up to 6 amperes at 110 or 220 volts. The break takes place in vacuum, preventing all danger in hazardous locations.

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Solenoid Water Valves

Automatic Products Co.

TWO new models are announced. Model 71 (illustrated) is for such applications as air conditioning, refrigeration and water-cooled compressor units. Its valve body is of extruded brass, doing away with leaks traceable to porous castings. Parts that come in contact with water are made of corrosion-resisting materials—the valve and seat design and materials in particular giving assurance against leakage, deposit and other troubles. This model is 4" high, 2" in diam., ⅜" pipe connection, 3/32" port opening, 75 gals. capacity at 45 lbs. pressure, 110 volt 60-cycle a.c. standard (others optional).

Model 76, for air-conditioning installations using greater volumes of water, has a solenoid-operated pilot whereby water pressure operates the ½" or ¾" pipe connection valve. Height, 7½" and diam, 2¼"; capacities 600 or 1350 gals.

Vectorial Components Measured Directly

By W. W. Parker*

DESIGNATED as the Westinghouse Universal Vectometer, a device has recently been built which directly measures a.c. quantities as scalar quantities and phase angles or as components with respect to any desired reference. Phase angles are read directly to a fraction of a degree on a vernier dial; components and scalar quantities of current and voltage are read directly from instruments shown in Fig. 1. Instrument impedances are such that they have negligible effect on the distribution of current and voltage drops. The direct measurement of vectorial relations is accomplished by the phase shifter-wattmeter circuit shown in Fig. 2.

The equipment consists primarily of the following:

1. A phase shifter.
2. An electrodynamometer for determining volts.
3. An electrodynamometer for determining amperes.
4. A milliameter for measuring the standardizing current.
5. A standardizing-current rheostat.
6. Switching equipment.
7. A positive phase-sequence network.
8. Balancing impedances.

The Meter Phase Shifter—The phase shifter has a 3-phase primary and a 2-phase 4-wire secondary balanced winding. The secondary is connected to the phase shifter secondary switch by which the phase position of the standardizing current can be shifted 90° by throwing this switch from the "in-phase" to the "quadrature" position. The rotor of the phase shifter is directly connected to a dial calibrated with a double scale divided into degrees and equipped with a vernier so that fractions of a degree can be read. In reading scalar quantities during a problem, the phase angle positions are read directly on the dial. The difference between the successive dial readings gives the phase displacement of the quantities.

The "Voltmeter"—The instrument used to measure volts is a moving-coil electrodynamometer, the fixed coil of which supplies the field which is energized from the standardizing circuit from the phase shifter. Since the deflection of a wattmeter is proportional to the product of the field current, the moving coil current and the cosine of the angle between these quantities, a zero deflection on the instrument is obtained when the standardizing current is in quadrature with the voltage being measured. A deflection proportional to the scalar voltage is obtained when the standardizing current is in phase with the voltage. The use of the phase shifter to supply the field energy makes possible the insertion of a high resistance in series with the moving coil so that the equivalent of a sensitive a.c. voltmeter is obtained. The "voltmeter" is ordinarily supplied with a 500 and a 50 volt scale. The "voltmeter" impedance is in the order of 60,000 ohms resistance for the high scale and 6000 ohms for the low scale, or in other words the sensitivity is about 120 ohms per volt.

The "Ammeter"—The instrument used to measure current is very similar in construction and operation to the one for measuring voltage. In this case, however, the fixed coil is used to carry the unknown current, the field being supplied by the moving coil which is connected across a shunt through which the standardizing current is passed. This method enables the use of lower impedance in the fixed coil winding than can ordinarily be obtained in a-c. current-measuring instruments.

Standardizing Circuit—The scalar magnitude of the standardizing current is measured by means of a standard milliameter and is adjusted when necessary by means of the standardizing current rheostat.

Switching Equipment—In addition to the phase-shifter-secondary switch mentioned above, there is a reversing switch which reverses the standardizing current so that no matter in what quadrant the quantity to be measured lies, a positive deflection can always be obtained on the instrument scales. This eliminates the use of a zero-center instrument so that the advantage of full-scale meters is obtained. A scale-changing and selector switch is also provided by which the equipment is connected to read either voltage or current over a very wide range of values.

Positive Phase-Sequence Network—A 3-phase positive phase-sequence network is supplied so that the voltage to the phase shifter will always be balanced regardless of unbalance in the line voltages. This is necessary in order that the rotating field in the phase shifter be uniform and perfectly balanced. The phase position and the dial electrical degrees will then always correspond regardless of the position of the phase shifter rotor. The magnitude of the standardizing current will then be constant except with change in the applied positive phase-sequence voltage. Variation in this is taken up in the standardizing current rheostat which was mentioned above.

Balancing Impedances—In addition to the positive phase-sequence network, in order that the field be uniform, it is necessary to see that no disturbance is caused by unbalanced load. In order to obtain a balanced load a dummy load is supplied with an impedance equal to the average impedance of the standardizing circuit. This dummy load is connected to the phase-shifter-secondary switch so that when this switch is operated, the dummy load and the standardizing circuit are interchanged. That is, when the standardizing circuit is connected to the quadrature coil of the phase shifter, the dummy load is connected to the in-phase coil, and vice versa. In this way the secondary load on the phase shifter is a constant.

Operation—The apparatus can be used to determine vector currents or voltages either as scalar quantities with a definite angular relationship, or as components with respect to any desired reference vector. A description of both of these methods follows:

To read the scalar voltage of a bus or circuit and components of current with respect to this voltage the procedure is as follows: (See Figs. 3 and 5.)

1. The Volt Ammeter switch is turned counter-clockwise to high or low scale position as required.

2. The Phase-Shifter-Secondary Switch is turned to the Quadrature position.

3. The Phase Shifter is rotated until the voltmeter indicates zero voltage (Standardizing current must be kept at 100% value). A very accurate setting for this zero position can be obtained by

*Switchboard Engineer, Westinghouse Electric & Mfg. Co.

Fig. 1

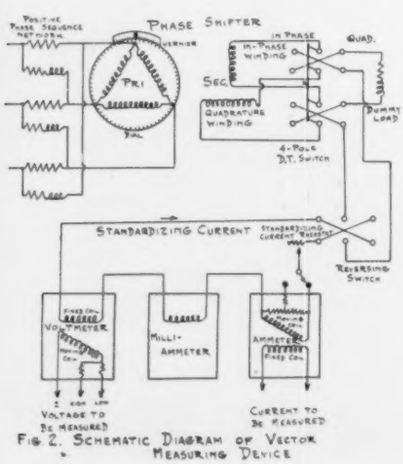


Fig. 2. Schematic Diagram of Vector Measuring Device

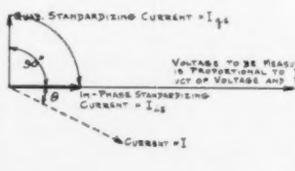

Quad. Standardizing Current = I_{qs}
30°
θ
Voltage to be Measured is Proportional to Product of Voltage and I_{qs}
In-Phase Standardizing Current = I_{qs}
Current = I

Fig. 3. To Obtain Scalar Voltage

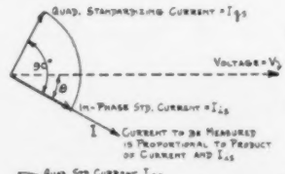

Quad. Standardizing Current = I_{qs}
90°
θ
Voltage = V
In-Phase Std. Current = I_{qs}
I
Current to be Measured is Proportional to Product of Current and I_{qs}

Fig. 4 To Obtain Scalar Current

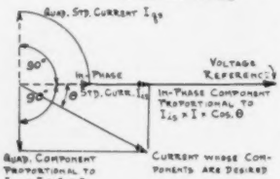

Quad. Std. Current I_{qs}
90°
In Phase
Voltage Reference
θ
Std. Curr. I_{qs}
In-Phase Component Proportional to $I_{qs} \times I \times \cos\theta$
Quad. Component Proportional to $I_{qs} \times I \times \sin\theta$
Current whose Components are Desired

Fig. 5 To Obtain Components of Current with Respect to a Voltage Reference

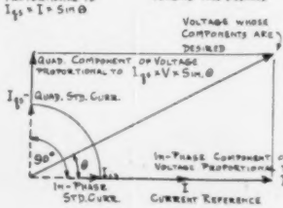


Fig. 6 To Obtain Components of Voltage with Respect to a Current Reference

using the reversing switch to determine the exact no-torque position. Reversing this switch when the standardizing current is practically in quadrature with the quantity being measured may give a movement of the needle which will indicate if the setting of the phase shifter is not exact. It is not always necessary to use this method of setting the phase shifter but when great accuracy is desired it will be found useful.

4. The Phase-Shifter-Secondary Switch is then turned to the "in-phase" position. The voltmeter will then read the scalar value of the circuit voltage being metered.

5. To read the in-phase component of current, turn the volt-ammeter switch to the proper ammeter scale, leaving the phase shifter in the reference position obtained from the voltage setting and the secondary switch in the in-phase position.

6. The out-of-phase current may be obtained by turning Phase-Shifter-Secondary switch to the Quadrature position.

Components of voltage with respect to a current reference are obtained in a similar manner (Figs. 4 and 6). In this case, the current phase position is obtained by using the quadrature coil of the phase shifter for the standardizing circuit and rotating the phase shifter until there is no deflection of the "ammeter." The standardizing circuit is then transferred to the in-phase coil and the scalar current is read. The volt-ammeter switch is then turned to the voltmeter position and the reading on the "voltmeter" will be the in-phase component of voltage. The standardizing circuit is then transferred to the quadrature coil and the reading on the voltmeter is the out-of-phase component of voltage.

In some cases it is desired to read the scalar quantities of both voltage and current and the angle between them. As is evident from the above discussion, the procedure is to obtain a phase angle reading of the scalar value of the currents or voltages by using the quadrature coil of the phase shifter, obtaining the zero torque position and reading the phase-angle position on the dial and then shifting to the in-phase coil of the phase shifter reading the scalar quantities. The angle between the quantities is the algebraic difference of the dial readings.

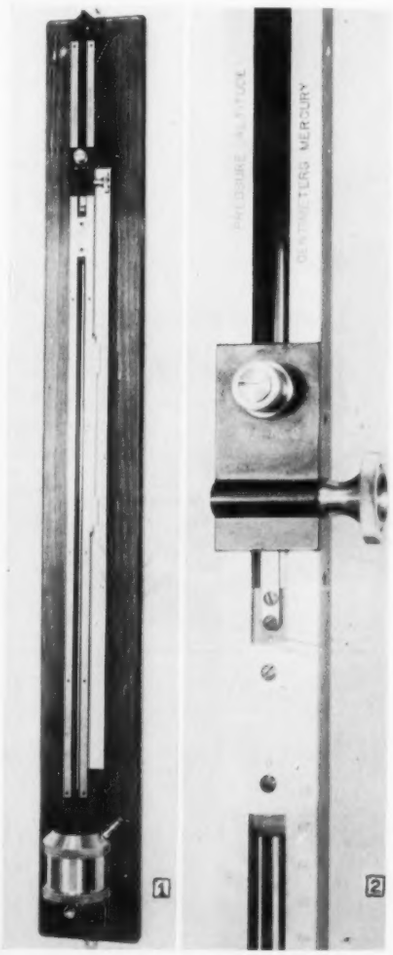
Applications—The Westinghouse Universal Vectometer is applicable wherever alternating voltages or currents are to be measured but especially as a convenient and rapid means of determining phase-angle relationships. It has especial adaptability for use in the electrical laboratory. It could be used not only in illustrating simple circuits but also to illustrate Kirchhoff's laws in complicated a.c. networks, and in connection with all power-factor measurements which are ordinarily obtained through the reading of volts, amperes, and watts and by means of slide rule operations. It readily admits itself to use in connection with the study of the symmetrical component method of analyzing unbalanced polyphase conditions as with it multiplication by j, a, and a^2 can be done simply by rotating the phase shifter through the proper number of degrees. One of its important advantages over existing laboratory methods of illustrating the behavior of a.c. circuits is that the student can obtain directly a visual indication of vector quantities and can plot any number of them directly from readings.

Fifty-thousand-foot Mercurial Barometer

Gaertner Scientific Corp.

IN testing and calibrating aeronautical instruments, actual barometric conditions under which they must function are accurately simulated in a bell jar by a suitable vacuum pump, and are observed by means of this new barometer, the Hg well of which is connected to the vacuum line.

This barometer, of a type recently designed and manufactured according to specifications of the U. S. Army Air Corps, is similar to the standard Fortin type, having a carefully selected uniform-bore Hg tube enclosed in a phosphor-bronze case. This case has a square cross-section instead of the usual round type, permitting the use of flat scales, easier to read than the usual curved type. A special vernier (Fig. 2), actuated by a rack and pinion, slides between them. One of the scales is graduated in units of 100′ from –1000′ to +35,000′ and in units of 200′ from +35,000 to +50,000′ with every 1000′ numbered; the other scale, graduated in mm. of Hg, is numbered every 10 mm. from 85 to 810. The special vernier permits reading it to 0.1 mm. Both scales are computed and specially graduated to compensate for the change of level of the Hg in the well. A thermometer, range +15° to +35° C., is mounted on the side of the barometer case.



The vernier is divided according to suggestions made by the Army Air Corps. Instead of having 9 mm. divided into 10 parts as usual, 19 mm. are divided into 10 parts, each division of the vernier being equivalent to 1.9 mm. rather than 0.9 mm., thus facilitating reading the instrument.

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"Automatic" Tube Tester

Burton-Rogers Co.

CALLED "automatic" because of the ease with which it tests tubes, the "Confidence Automatic" instrument gives readings of tube condition "in English." The operation consists (after adjusting voltage when first setting up) of pointing the selector to the number of the tube to be tested, putting the tube in the proper socket (all sockets plainly marked) and reading the instrument dial.

A special transformer with multiple secondaries is so designed that automatic cut-off of plate current takes place which allows the tube under test to flatten its

plate current curve against a fixed bias, giving a test conforming to both plate current and mutual conductance. Relationship between the transformer current limits, hot resistance of the protective pilot lamp, and the multiple meter shunts gives automatic protection to the meter under all conditions. The instrument cannot be injured by the act of testing tubes or by short-circuited tubes. The pilot lamp, located in the plate return circuit, will light and give visual evidence of any short circuit: plate to grid, cathode, filament, or suppressor grid; also from

screen-grid to any of these elements. Short-circuits from cathode to heater are indicated by pressing the button which opens the normal cathode-heater connection. This helps in the location of noisy tubes.

The interpretations of tube condition are based on an equitable reading for both tube manufacturers and consumers. The calibration is based on the standard characteristics of all types of tubes.

Portable and counter-display models, as illustrated, are supplied by the makers.

Paper Testing Instruments Make Possible New Tests

R. Fuess, Inc.

1. THE BEKK SMOOTHNESS AND POROSITY TESTING APPARATUS

DESIGNED and mechanically perfected by Fuess engineers from the specifications of the Laboratory Head and Technical Director of a large German press, this new tester (Figs. 1 and 2) makes possible quantitative measurements of properties hitherto determined qualitatively. Moreover, its extreme sensitivity makes possible the measurement of slight differences between papers hitherto considered "equal," and even the measurement of variations of smoothness of a single sheet—which by previous methods would have been considered "absolutely uniform."

Measuring Smoothness—The method is based on the fact that the closeness of contact between a flat rigid surface and a paper surface depends on the smoothness of the latter. The determination consists in measuring the rate of escape of air between the test surface and a standard flat surface applied under standard load—the air suction conditions also being standard. The following translation explains both the procedure and the principle.

Cut out from the paper being tested, a few strips about 5x5 cm. from places where there are no imperfections, and mark wire and felt side. The side to be tested is laid on surface 4. The square of soft gum rubber is laid on the paper; on top of rubber, the disk 6. Then, lever 8 is brought down on the disk, producing a pressure on the paper of 10 kg. or, 1 kg./cm.^{2} Using hand pump 22 (first turning stop cock 3 on) causes the mercury column to rise. When column reaches slightly above calibration 380 (G_1) the stop cock is turned off, and the mercury column is stationary. Turning on stopcock 3, the mercury column will begin to drop, and with a stop watch, the time is noted which it takes to drop from 380 (G_1) to 360 (G_2). The times vary between 5 seconds and 30 minutes according to the kind of paper tested, whence it follows that a proper characterization of the paper surface can be secured.

The above refers to the standard test, with a load of 10 kg. The Bekk tester also permits making tests at other pressures. Thus a printer can determine which of two papers giving the same reading at 1 kg./cm.^{2} is *effectively* smoother under the conditions of a particular job at a higher pressure. For this purpose, supplementary weights (10) are laid on lever 8.

Measuring Porosity—The Bekk Tester is readily used for measuring porosity. The procedure is similar to that followed for measuring smoothness.

Strips 2.5 x 2.5 cm. are used. The strip is placed (without rubber disk) on surface 4 and on it is placed the pressure disk for porosity testing. Lever 8 is then lowered, and supplementary weight 10 placed in its position. The Hg column is run up to 482 mm. on the scale (P_1) and the time noted with a stop watch for the column to drop to 282 mm. (P_2). This fall of Hg corresponds to the passing of 100 cm.^{3} of air through 1 cm.^{2} of paper surface by an average suction of ½ atmosphere. The testing time varies from 2 seconds to 100 minutes depending on the kind of paper.

2. THE DUSTING OR FUZZ TESTER

This is the tester designed by Prof. Dr. Riesenfeld and Dr. Hamburger. Its operation (see Fig. 3) is simple. From the papers to be compared, test strips 500 mm. long by 30 mm. wide are cut. A strip is wound on the wheel and locked in place. Against the paper surface a razor blade rests easily, held under a constant pressure by a holder. The pressure is regulated as desired for the test, by setting the beam weight. The paper is weighed before the test; and after the wheel has made so many revolutions the paper is taken off and again weighed. The loss caused by the "dusting" action of the friction blade forms a suitable comparison between papers being tested for their dusting or "fuzz" properties.

3. STIFFNESS TESTER

Designed by the designers of the Fuzz Tester, this simple instrument makes possible comparisons of stiffness of papers. The principle is based on the fact that a horizontally stretched test strip of paper will bend under its own weight in proportion to its stiffness; and the deflection is read off on the scale, for purposes of comparison.

Ten strips are cut to size, from the papers being compared, with a steel die furnished. There are ten steel holding-blocks, each block holding one end of a strip, the other end of the strip being free. After a fixed time, about 15 minutes, the ten blocks are successively placed in the instrument, and the deflection of the free end of the strip read off on the scale. This test is naturally adaptable to varieties of paper only which possess more or less the same weight per unit, but weight differences up to 10% only imperceptibly influence the result, so that the comparison of kindred grades appears quite accurate. The stiffness of a paper is also dependent on its humidity content so that it is necessary to carry out the tests in air of approximately the same degree of humidity.

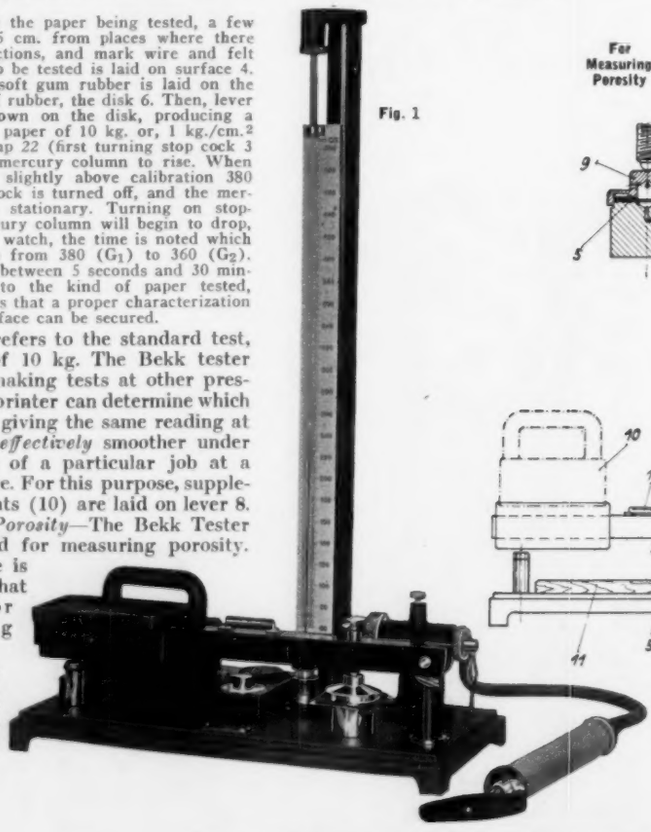


Fig. 1

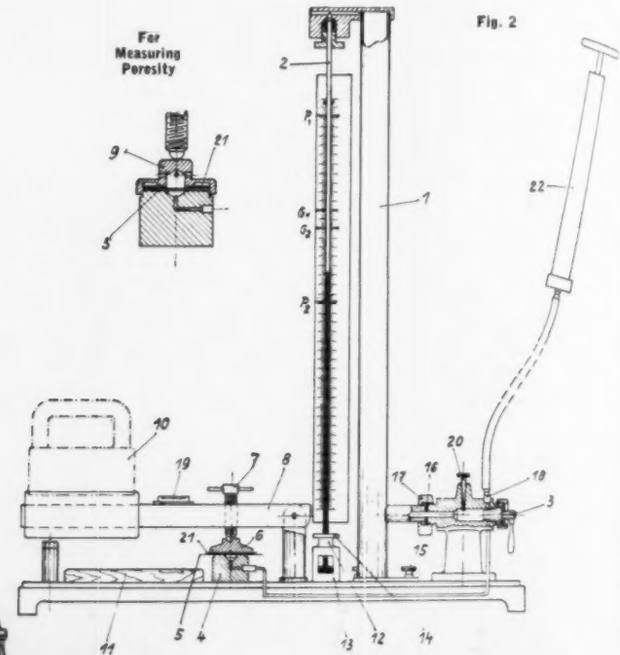


Fig. 2

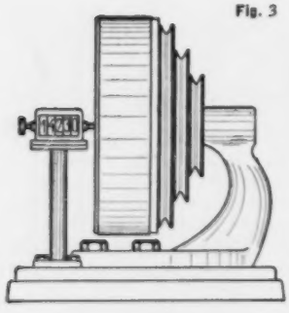
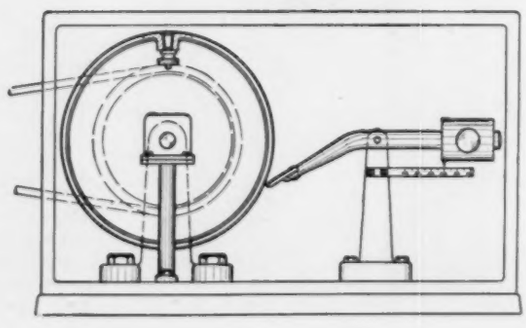


Fig. 3



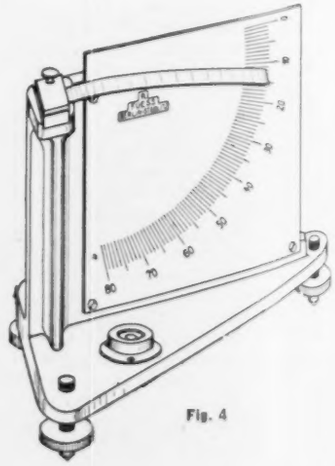


Fig. 4

The Edgerton Brilliant-illumination Stroboscope

General Radio Co.

A RECENT development of Prof. Harold E. Edgerton, Massachusetts Institute of Technology, this firstling in the 1933 crop of new instruments is of the intermittent light-source type—which type has heretofore depended chiefly on neon lamps to furnish the requisite brief flashes. Prof. Edgerton has adapted the technically desirable mercury-arc lamp to modern stroboscopic requirements.

In the Edgerton Stroboscope now announced by the above company, the flash lasts 5 microseconds—in which time an object traveling at a mile a minute moves only 0.005". The flash speed can be controlled accurately over the entire range ordinarily required and fundamental synchronism can be obtained up to speeds of 10,000 r.p.m. This short, brilliant flash is obtained by discharging a capacitor across a mercury-arc tube which has the form of an inverted U with internal electrodes of mercury, anode and cathode, at its lower ends.

Provision is made for flashing the light in exact synchronism with the closing of a pair of electrical contacts, by the 60-cycle supply mains (60 flashes per second), or by any external source of a.c. The maximum speed of the present equipment, determined by the regulation of the rectifier unit, is in excess of 150 flashes per second, so that fundamental synchronism may be obtained at all speeds from zero up to at least 10,000 r.p.m., while perfect synchronism of the second or third order will double or treble this limit.

All parts of the stroboscope equipment, except the lamp and the tripping contacts, are built into a metal cabinet which constitutes the power supply. This is energized directly from 110-volt, 60-cycle mains and consumes a maximum power of about 0.25 kw. Only three adjustable controls are required: the size of the lamp capacitor, a rheostat for controlling the intensity of the flashing voltage, and an adjustable speed contactor (if used). A synchronous-motor friction-driven variable-speed contactor, which is optional, and which is shown being adjusted by the operator in the photograph, has a continuously adjustable range of operation from 5 to 30 flashes per second. While this gives fundamental synchronism for 300 to 1800 r.p.m., it may, of course, be used at perfect synchronisms for higher speeds. The phase of the contacts may be adjusted at will by rotating the head of the contactor. The contactor mechanism may be detached from the motor drive and driven by any centered, rotating shaft, in the manner of a tachometer. The contacts will then be operated in exact synchronism with the rotation of the shaft.

Referring to the schematic wiring diagram, a full-wave thermionic rectifier containing the customary elements is used to feed energy into a reservoir capacitor C_1. The energy in the reservoir capacitor is subsequently fed into lamp capacitor C_2 which, in turn, discharges directly through the mercury-arc lamp whenever the latter is flashed. Resistor R and choke L permit capacitor C_2 to be instantaneously discharged completely through the lamp so that the voltage on C_2 may be reduced momentarily to zero or slightly reversed, irrespective of the voltage which may exist upon reservoir capacitor C_1. Thus the lamp becomes extinguished immediately after it is flashed. The time constant of the discharge circuit of C_2 across the anode and cathode of the lamp (shown in heavy lines) determines, primarily, the duration of the light impulse. If the lamp becomes overheated, however, the exposure increases somewhat.

The voltage supplied across the anode and cathode of the lamp is not sufficient, of itself, to flash the lamp. An auxiliary "flashing voltage" is used for striking the arc: a high-tension surge of several thousand volts is applied between the cathode and a flashing electrode which consists of a metal band around the tube near the cathode. The flashing potential, obtained through a high-ratio air-core transformer, creates an electrostatic field of sufficient intensity to ionize the gas in the vicinity of the cathode.

In order to obtain sudden surges of current through the primary of the flashing transformer, some form of timing relay must be used. A most satisfactory relay for this purpose is the mercury-vapor triode known as Type FG-17 Thyratron in which the anode-cathode circuit, while normally open, becomes essentially short-circuited whenever the grid is subjected to a suitable stimulous. The timing mechanism to stimulate the grid so as to trip the thyratron, and hence flash the lamp, may consist of the closing of a pair of electrical contacts or be each positive peak of an alternating current of suitable frequency.

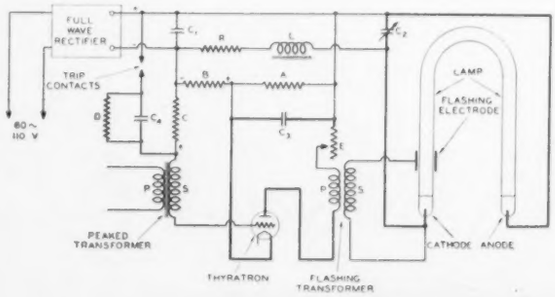
The two resistors A and B constitute a voltage divider across the high-voltage rectifier, A being several times larger than B. The grid of the thyratron is given a sufficient negative bias by means of the voltage drop across B to maintain the anode circuit open. At the same time, condenser C_3 is normally charged to nearly the full potential of the rectifier.

Whenever the thyratron is tripped the energy stored in C_3 discharges through the low-resistance circuit (shown in heavy lines) comprising the thyratron anode-cathode circuit, the primary of the flashing transformer, and control resistor E. Resistor A is thus virtually short-circuited so that the full voltage of the rectifier appears across B. The grid of the thyratron is, accordingly, given a sudden and very strong negative bias since the cathode is raised nearly to the potential of the anode. Thus the sudden rush of discharge current from C_3 flowing through the flashing transformer will last only for a brief interval (determined by the de-ionization time of the thyratron). The very rapid rise of the primary flux in the air-core flashing transformer develops a sudden and intense potential which is supplied to the flashing electrode and serves to strike the arc.

Tripping the thyratron is accomplished as follows: As stated above, the thyratron grid is sufficiently negative to maintain the anode circuit normally open. If, now, the tripping contacts are closed, the sudden rush of charging current into condenser C_4, passing through resistor C, will develop across this resistor a momentary positive bias for the grid which may overbalance the negative bias due to B, so as to trip the thyratron and produce the sequence described above.

The thyratron is tripped at the first instant at which the contacts are closed and the duration of the contact is immaterial provided that resistor C is sufficiently small in comparison with D so that voltage divider C-D does not maintain a sufficiently positive bias on the grid to continually overbalance the normal negative bias due to B. As soon as the contacts are opened, condenser C_4 discharges through D and is ready to receive a new charging current when the tripping contacts are subsequently closed.

If the tripping contacts are left open and if an a.c. is applied through the primary of the peaked transformer, then at each alternate half cycle which swings the grid positive, the thyratron will be tripped and the lamp flashed.



New Types of Temperature and Pressure Controllers

Minneapolis-Honeywell Regulator Co.

SEVERAL new types of automatic temperature controllers, pressure controllers, combination instruments and pressure switches have each been developed in several models by the above company, so that the total number of different instruments covers a wide variety of applications, but all of them, in virtue of certain features common to them and to no other instruments, belong to one family possessing definite characteristics. Instruments of this new line are available for temperatures from those of refrigeration work to a maximum of 700° F., for gage pressures up to 150 lbs. and for differential pressures up to 16 lbs., but the following describes specifically only the refrigeration controls and the steam boiler pressure-operated switches.

Fig. 3 is a single-system pressure operated limit switch known as Type L Pressuretrol. It differs from other Minneapolis instruments known as Pressuretrols, and it bears a strong family resemblance to the instruments shown in Figs. 1 and 2.

A noteworthy "family feature" of all these new instruments is shown in Fig. 4 (a side view of one of the refrigeration instruments). It consists of visible scales —one for the main-range setting point and one for setting the differential. These settings are made by adjusting the length of coil springs in tension between levers and axial screws. The heads of the two adjusting screws protrude above the top of the case and are cross-drilled to take a standard wire and lead seal, permitting adjustments to be locked by accredited service men.

trarily graduated for indication and reference purpose, the value of each division being approx. 2° F. The action of the differential mechanism is independent of the cut-off point, and at each position on the scale the amount of differential increase is additive to the minimum differential of the instrument.

The high pressure cut-out element mounted on the Type T413-1 is a self-contained system consisting of bellows, spring, adjustment nut and small parts arranged to tilt the switch to an off position when excessive pressure develops. The differential between cut-in and cut-out on this element is not adjustable.

Refrigeration Pressure Controls differ from the foregoing in that instead of a thermostatic system there is a pressure system which is connected in the suction or "low side" line of the installation. As the pressure rises, the bellows expands and transmits its movement to the main lever as explained above.

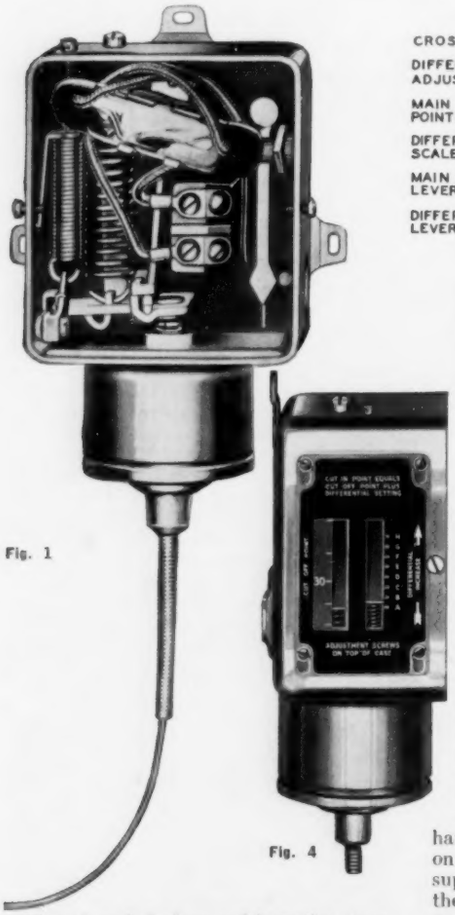


Fig. 1

Fig. 4

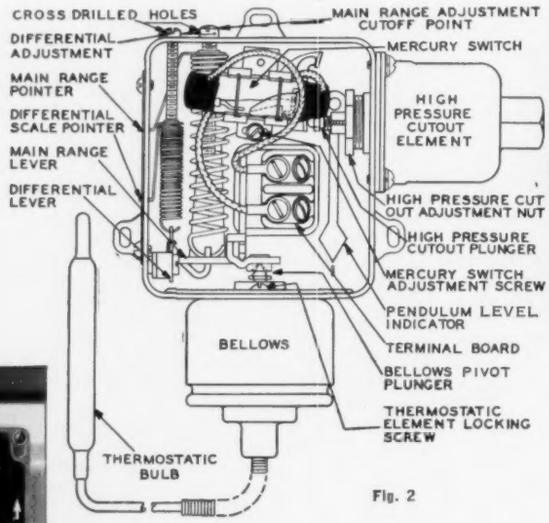


Fig. 2

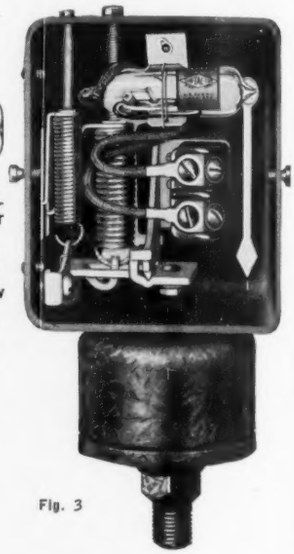


Fig. 3

Figs. 1 and 2 show refrigeration controls the function of which is to maintain a constant temperature by intermittent control of the refrigeration machine. Type T414-1 (Fig. 1) may be used with all types of machines; while Type T413-1 (Fig. 2) embodies a high-pressure cut-out and is designed for certain types of machines.

These same Figs. 1 and 2 may serve to illustrate refrigeration pressure controls the construction of which differs in that a low-pressure element (see lower part of Fig. 3) is incorporated instead of the bellows end of thermal systems. Correspondingly, one type has a high-pressure cut-out in addition to the main pressure element and is designed for use on certain types of machines.

Refrigeration Controls (Figs. 1 and 2) have gas-filled, remote-bulb thermostatic elements terminating in bellows which elongate or contract in accordance with changes in bulb temperature. The visible scales thus indicate the bulb temperature, which is the "box temperature" only when the bulb is so located as to be affected by the box temperature. The mechanism operated by the bellows consists of a wide main lever provided with hardened fulcrum grooves which pivot on widely spaced hardened knife-edge supports. Integral with the main lever is the main operating lever which is balanced by the main adjustment spring and which tilts the mercury switch. The action of the differential adjustment spring is transmitted to the main operating lever through a uniquely designed auxiliary lever so positioned as to impose the additional tension necessary to increase the temperature differential. The mercury switch is of a new "heavy-duty ceramic type" adequate for the majority of commercial applications. Since the thermostatic element is self-contained and removable, emergency replacement is readily accomplished on the job, following which recalibration is likewise a simple matter.

The minimum differential between "cut-off" and "cut-in" is approximately 2½° F. The differential scale is arbi-

The cut-off pressures are constant for any particular setting of the main range adjustment. The differential adjustment regulates the cut-in points for values greater than the minimum differential inherent in the control. The differential mechanism through its lever and spring acts to impose additional load on the main lever, raising the cut-in point to a value proportional to the differential spring tension. The action of the differential mechanism is independent of the cut-off point.

The high-pressure cut-out element of the L413-1 is connected to the high side of the compressor. When dangerous pressures develop the bellows is compressed against the spring, tilting the switch to an "off" position. As the pressure drops the spring elongates the bellows and tilts the mercury switch to an "on" position.

The Type L Pressuretrols (Fig. 3) are designed to serve as limit switches for automatically-fired steam boilers. They shut down the heating plant when pressure rises beyond the "off" point, and dropping pressure returns the mercury switch to the "on" position. They may be used in dual control (electrically in series) with room thermostats, thus serving as safety devices for the boiler, or they may be used without thermostats as the primary operating control governing the heating plant.

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Literature on the equipment used by operators or automatic controllers to perform their control functions is covered under this heading. For example, the drum controller and associated switches, rheostats, relays, and motor starters by which an operator controls the motion of a crane are all pieces of "control functioning equipment."

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(Continued on Page A7)

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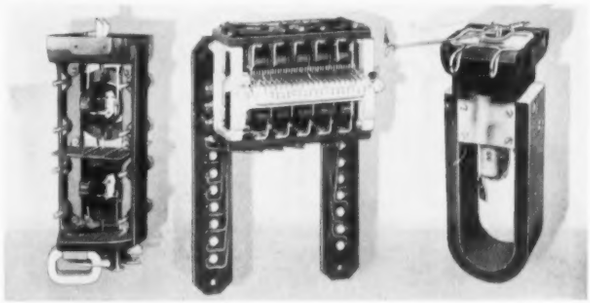

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Brown Instrument Co.
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Esterline-Angus Co.
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Taylor Instrument Companies

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Taylor Instrument Companies
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Bailey Meter Co.
Baldwin-Southwark Corp.
Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Taylor Instrument Companies
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Bristol Company
Defender Automatic Regulator Co.
Foxboro Co.
Taylor Instrument Companies
Electrically Operated
Baldwin-Southwark Corp.
Bristol Company
Brown Instrument Co.
General Electric Co.
Taylor Instrument Companies
Motor Operated
Baldwin-Southwark Corp.
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Bailey Meter Co.
Taylor Instrument Companies
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Bristol Co.
Brown Instrument Co.
Defender Automatic Regulator Co.
Foxboro Co.
Taylor Instrument Companies

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ADVERTISERS' INDEX

B
Bailey Meter Company 7
Bristol Company ..... Back Cover
Brown Instrument Company ..... Inside Back Cover

E
Esterline-Angus Co. A3

F
Foxboro Company, Inc. A2

G
Gaertner Scientific Corp. 3
General Electric Co. A8
General Radio Co. A3

H
Holtzmann, Emil 6

J
Journal of Scientific Instruments A5

M
Morey & Jones, Ltd. 8

R
Rawson Electrical Instrument Co. 8
Review of Scientific Instruments A5
Rubicon Company A8

T
Taylor Instrument Companies ..... Inside Front Cover

V
Veeder-Root, Inc. A8

Measurement Theory (1.1)

Recent Developments in Magnetic Units. A. E. KENNELLY. *Electrical Engineering*, Vol. 51, May 1932, pages 343-345.

The paper bares the ambiguity and misunderstanding in the definitions of magnetic units. The only c.g.s. magnetic units so far adopted internationally are the following:

Unit	*Symbol*	*Name*
Magnetomotive Force	F	gilbert
Magnetizing Force	H	oersted
Magnetic Flux	Φ	maxwell
Flux Density	B	gauss

The transactions of the various international committees are reported in some detail and the work yet to be done outlined. Ha (1.1)

The Units of Electrical Resistance. H. B. BROOKS. *Electrical Engineering*, Vol. 51, May 1932, pages 338-341.

The history of the development of the ohm as unit of resistance is given and methods of making absolute measurements are briefly described. The legalization of absolute units so far still lacking is strongly recommended. Ha (1.1)

Some Measuring Properties of Instruments. M. F. BÉHAR. *Scale Journal*, Vol. 18, April 1932, pages 4-5, 9.

The significance of various terms used in measurements, as accuracy, error, sensitivity, lag, sluggishness, etc. of instruments is explained and the terms defined. An absolute criterion of "accuracy" is proposed. Ha (1.1)

A General Theory of Systems of Electric and Magnetic Units. V. KARAPETOFF. *Electrical Engineering*, Vol. 51, April 1932, page 264.

As there are now in use several systems of units, (C.G.S., practical, Gauss and Lorentz-Heaviside) the author points out that a system of electric and magnetic units must be characterized by five parameters: a numeric, p, defined by the corresponding ratio of magnetic flux densities; a conversion factor, k, for conversion of a given volume of current into the corresponding magnetomotive force; the absolute permittivity, n, and the absolute permeability, μ; these parameters must satisfy the equation $vk = np/k\mu$ where v is the velocity of propagation of electromagnetic waves in that medium to which k and μ refer. By giving these parameters specific values seven different systems of units are derived, namely the electrostatic, the electromagnetic, the practical, the Gauss, the Heaviside-Lorentz, a compromise system, and an ampere-ohm system. Four fundamental units are necessary for a system. A table of the physical dimensions of various units is added. Ha (1.1)

Electrical Units and Their Application. L. T. ROBINSON. *Electrical Engineering*, Vol. 51, May 1932, pages 335-338.

The relations of the electrical units to the fundamental units of length, mass and time are explained, and the progress which has been made during the last 15 to 20 years in the accuracy of determining the volt, the ampere, and the ohm is discussed. The most exact measurements now have an accuracy of 1 to 10^5; practical measuring instruments often show an accuracy of $1/10^4$. Ha (1.1)

Suggestions of the Terminology Committee of the German Society of Applied Optics. (Vorschlaege der Kommission fuer Bezeichnungsfrage der Deutschen Gesellschaft fuer angewandte Optik.) *Zeitschrift fuer technische Physik*, Vol. 12, Nov. 1931, pages 601-603.

Terminology and abbreviations approved by the Committee in June, 1931. EF (1.1)

Graphical Representation of Systems of Units. (Graphische Darstellung von Massystemen.) H. WUEGER. *Bulletin, Association Suisse Des Electriciens*, Vol. 22, Dec. 26, 1931, pages 637-640.

The members of a system of units are represented graphically in a three-dimensional rectangular coordinate system. The powers of the three basic dimensions are placed on three axes and all other units inserted in their corresponding places. The relation between the various units and their dimensions, especially of electrical units, can be found at a glance. WR (1.1)

Measurement Practice (1.2)

International Standard of Electromotive Force. MARION EPPLEY. *Electrical Engineering*, Vol. 51, May 1932, pages 341-343.

The properties of the cadmium cell and its suitability for use as a standard cell are explained and the differences in the standard values of the volt as used in different countries are discussed. Its use in connection with a potentiometer is described; the value adopted by the U. S. A. is now 1.01830 volts at 20°C. Not more than 0.0001 ampere should be drawn from the cell. Precautions to be observed in the use of the cell are given. Ha (1.2)

Correctness, Accuracy and Sensitivity of Measuring Tools. (Richtigkeit, Genauigkeit und Empfindlichkeit der Messwerkzeuge.) M. KURREIN. *Messtechnik*, Vol. 8, March 1932, page 61; *Zeitschrift für Instrumentenkunde*, Vol. 51, Oct. 1931, page 541-545.

These three properties are defined as follows: 1. The sensitivity is the smallest change of the instrument which gives a clearly visible change in the indication. 2. The accuracy is that smallest change of the measured quantity which is still clearly indicated by the measuring device within the inaccuracy due to the sensitivity. 3. The correctness only gives the relation between measured quantity and indication which, in each case, is determined by the calibration curve. These definitions are explained and derived at length. Ha + EF (1.2)

Sensitivity of Instruments. GEO. KEINATH. *Archiv für Technisches Messen*, Vol. 1, March 30, 1932, section J022-1, page T22.

The sensitivity of an instrument is defined as the deflection of the index per unit of the quantity to be measured; the greater the sensitivity the greater the deflection. How the sensitivity changes with the type of instrument and over the scale is explained and a table is given showing the deflections in mm. for one millionth or thousandth watt or thousandth ampere and the resistance of moving system of the instrument. Ha (1.2)

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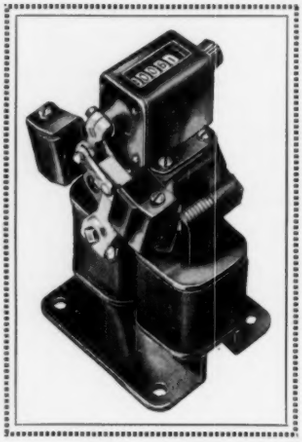

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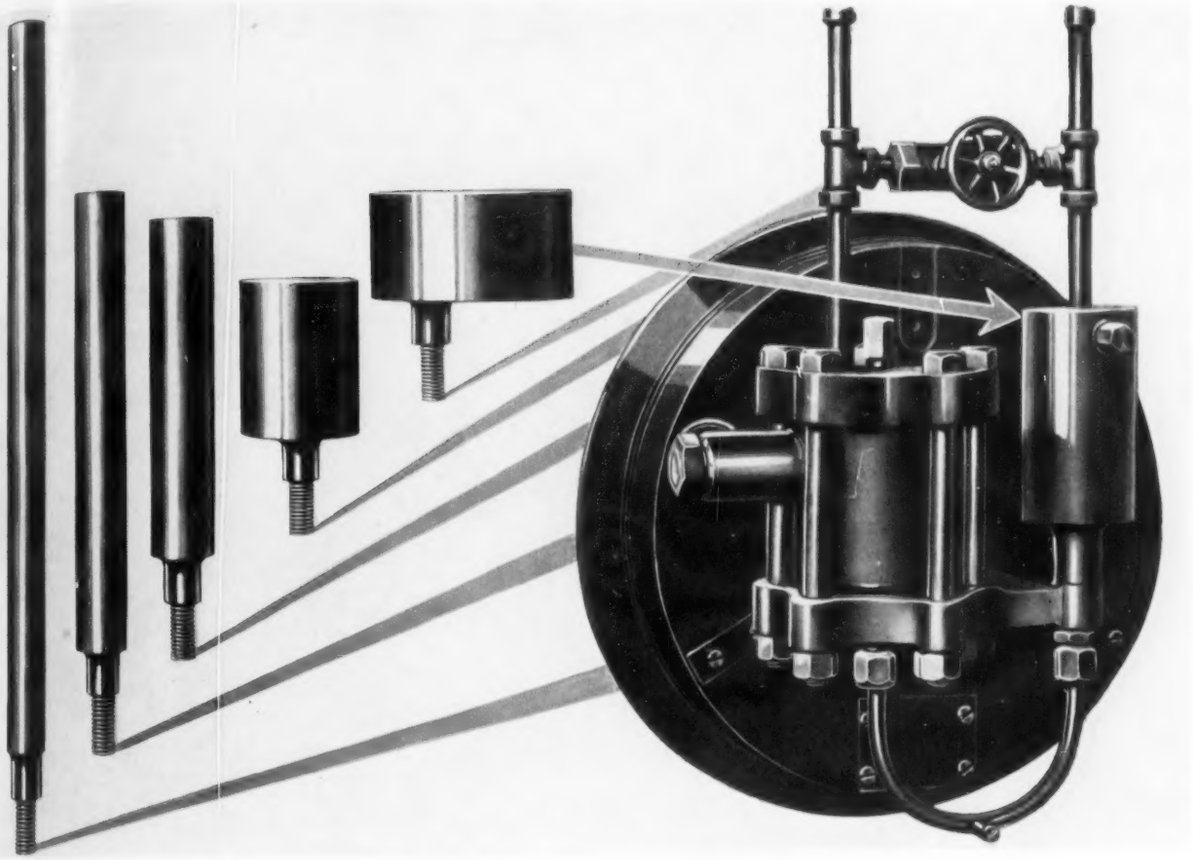

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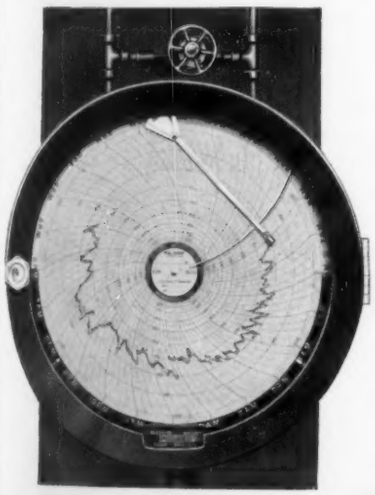

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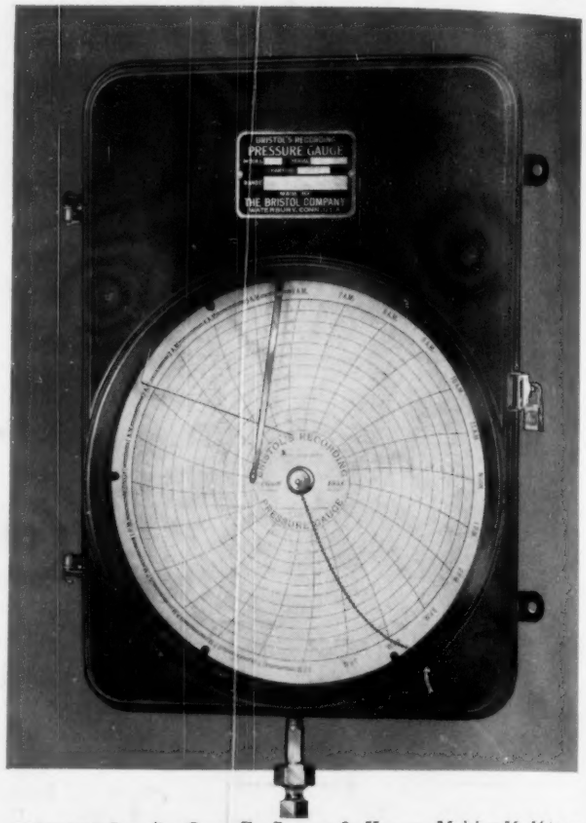

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Chemicals	X	X	X	X	X	X	X	X	X	X	X
Coke	X	X				X	X	X		X	X
Drugs, Cosmetics	X	X		X	X	X	X	X	X	X	X
Explosives	X	X	X	X		X	X	X	X	X	X
Fertilizers	X	X		X		X	X	X		X	X
Glass	X	X		X				X		X	X
Glue, Adhesives	X	X		X	X		X	X	X	X	X
Leather	X	X					X	X	X	X	X
Lime, Cement	X							X		X	X

INDUSTRY \ PROCESS	Liquid Handling	Gas Handling	Chemical Reaction	Separation Of Materials	Evaporation	Distillation	Heat Transfer	Process Heating	Refrigeration	Steam Generation	Plant Heating
Manufactured Gas	X	X						X		X	X
Oils, Greases	X	X		X		X	X	X	X	X	X
Paints, Varnish	X	X						X		X	X
Paper, Pulp	X	X	X	X	X		X	X		X	X
Petroleum Refining	X	X	X	X		X	X	X	X	X	X
Rayon	X	X	X				X	X	X	X	X
Rubber	X	X	X					X		X	X
Soap	X	X			X	X	X	X	X	X	X
Sugar	X	X		X	X		X	X	X	X	X
Other Industries	X	X					X	X	X	X	X